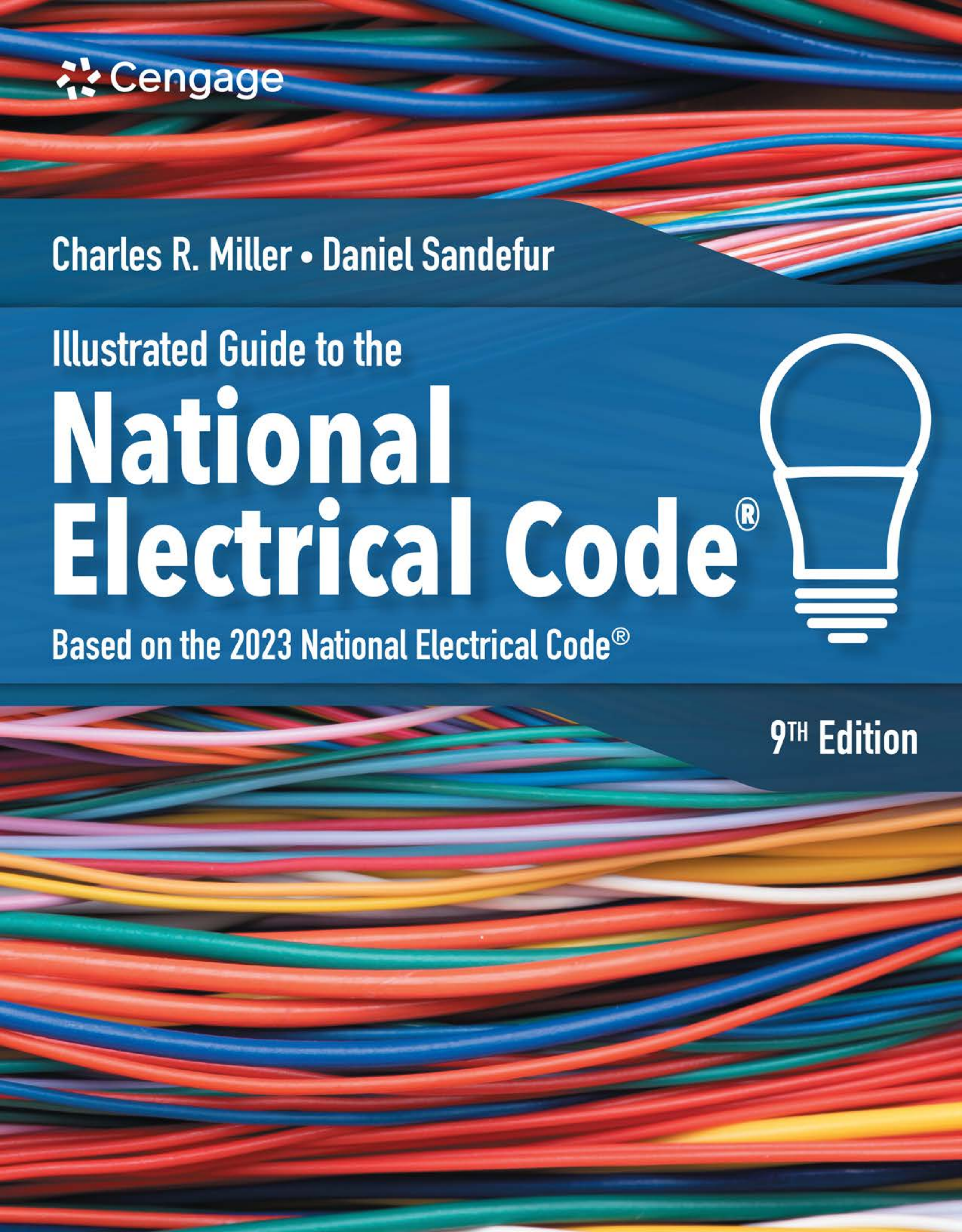

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Charles R. Miller • Daniel Sandefur

Illustrated Guide to the National Electrical Code®

Based on the 2023 National Electrical Code®

9TH Edition

Charles R. Miller • Daniel Sandefur

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Charles R. Miller / Daniel Sandefur

SVP, Product: Cheryl Costantini

VP, Product: Thais Alencar

Portfolio Product Director: Jason Fremder

Portfolio Product Manager: Alice Willenbrink

Product Assistant: Jannell Whitted

Learning Designer: Mary Clyne

Senior Content Manager: Cheri Plasse

Digital Project Manager: Elizabeth Cranston

VP, Product Marketing: Jason Sakos

Director, Product Marketing: Neena Bali

Product Marketing Manager: Morgan Gauthier

Production Service: Lumina Datamatics Ltd.

Designer: Timothy Biddick

Cover/Interior Image Source: Miroslaw Nozka/
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Preface

We wrote this text to serve first-time students and practicing electricians alike. This guide's objective is to provide the information needed to complete your project—without the necessity of learning the *NEC* from cover to cover. *Illustrated Guide to the National Electrical Code®* will bring your project to life as quickly and as accurately as any text on the market today. Whether you are an electrician's apprentice, a master electrician, or an electrical inspector, this unique resource has something for you.

Our Approach

Illustrated Guide to the National Electrical Code® offers an exciting new approach to understanding and applying the provisions of *the National Electrical Code*.* Unlike the *Code*, this text gathers and presents detailed information in a format, such as one-family or multifamily dwellings, based on "type of occupancy." Code specifications applicable to a given type of occupancy are logically organized in easy-to-read units and graphically enhanced by numerous technical illustrations.

Going an extra step, the occupancy-specific material is subdivided into specific rooms and areas. Information relevant to more than one type of occupancy is organized into independent units for easier reference. For instance, items such as raceways and conductors are covered in Unit 5 and are related to every type of occupancy.

Organization of the Text

Students who wish to acquire a comprehensive grasp of all electrical codes will want to study this text section by section and unit by unit. Practicing electricians who have specialized in one type of occupancy and wish to understand an unfamiliar segment may want to focus on those new areas. For example, an electrician who has been wiring commercial facilities for a number of years wants to wire a new house. Being unfamiliar with the codes concerning residential wiring, this individual can turn to Section 2, "One-Family Dwellings." Here, everything from receptacle placement to the placement of the service point is explained. Section 2 is made up of four units: Units 6 through 9. Unit 6, "General Provisions," contains general requirements for one-family dwellings, both interior and exterior. Unit 7, "Specific Provisions," addresses more complex issues that require additional provisions for specific areas such as kitchens, hallways, clothes closets, bathrooms, garages, and basements. Unit 8, "Load Calculations," simplifies the standard as well as optional load calculation methods for one-family dwellings. Unit 9, "Services and Electrical Equipment," is divided into five sections: "Service-Entrance Wiring Methods," "Service and Outside Wiring Clearances," "Working Space around Equipment," "Service Equipment and Panelboards," and "Grounding."

New to This Edition

The 9th edition has been thoroughly revised and updated to reflect the 2023 *National Electric Code®*. Important updates include:

- New Ground-Fault Circuit Interrupter (GFCI) requirements
- New box fill requirements
- Relocated, new, and revised definitions
- Revised load calculations

Features of the Text

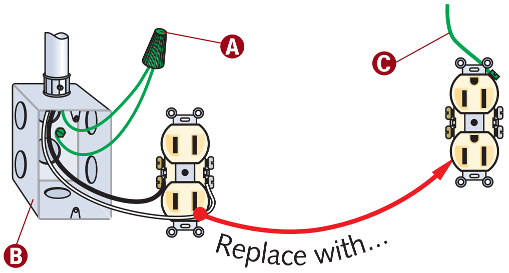
Illustrated Guide to the National Electrical Code® takes a uniquely visual approach to delivering important *Code* information. Throughout the chapters, you will find text explanations keyed to accompanying illustrations for reinforcement.

Grounding Means Present or Installed in the Enclosure

Ⓐ A grounding-type receptacle shall be installed in any receptacle enclosure having a grounding means »*406.4(D)(1)*«.

Ⓑ If an equipment grounding conductor is installed and connected to the grounding electrode system in accordance with 250.130(C), a grounding-type receptacle shall be installed »*406.4(D)(1)*«.

Ⓒ A grounding-type receptacle shall be connected to the equipment grounding conductor in accordance with 406.4(C) or 250.130(C).



Code references are clearly marked as follows for easy reference:

> Each receptacle must be readily accessible from grade and located not more than 6 ft, 6 in. (2.0 m) above grade level »*210.52(E)(1)*«.

Notes, cautions, and warnings provide practical advice for electricians throughout each chapter.

Each unit concludes with a thorough competency test to give students practice navigating the code, identifying the applicable section, and applying it to real-world situations.

In the electrical field, as in any career, the learning experience never ends. We believe you will find this text to be a valuable addition to your reference library. In fact, you may want to include it in your toolbox or briefcase!

Important Notes about the *NEC*

The "what," "when," and "where" adoption of the provisions of the *NEC* is under the discretionary control of state and local jurisdictions. State and local jurisdictions also have the liberty of appending additional codes, which in many cases may be more stringent than those outlined by the *NEC*. The *Code* may be adopted in whole or in part. For example, while some local codes do not allow the use of nonmetallic- sheathed cable for residential or commercial wiring, others allow its use in residential but not in commercial wiring applications. To ensure compliance, obtain a copy of any additional rules and regulations for your area.

Take note that this guidebook was completed after all the normal steps in the National Fire Protection Association (NFPA) 70 review cycle—Public Input, First Draft Report, Public Comment, Second Draft Report, reviews by Technical Correlating Committee, NFPA Annual Meeting, and ANSI Standards Council—and before the actual publication of the 2023 edition of the *NEC*. Every effort has been made to be technically correct, but there is always the possibility of typographical errors or appeals made to the NFPA Board of Directors after the normal review cycle that could change the appearance or substance of the *Code*. If changes do occur after the printing of this book, they will be included on the Instructor Companion Site and will be incorporated into the guidebook in its next printing. Note also that the *Code* has a standard method to introduce changes between review cycles, called "Tentative Interim Amendment," or TIA. These TIAs and corrections of typographical errors can be downloaded from the NFPA Web site, www.nfpa.org, to make your copy of the *Code* current.

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The MindTap for Illustrated Guide to the *NEC*, 9th Edition, offers a complete digital course experience for students and teachers. This MindTap is highly customizable and combines assignments, videos, simulations, quizzes, and lab exercises, along with the enhanced ebook. MindTap enables students to directly analyze and apply what they are learning and allows teachers to measure skills and outcomes with ease.

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Additional instructor resources for this product are available online. Instructor assets include an Instructor's Manual, Solution and Answer Guide, PowerPoint® slides, Educator's Guide, and a test bank powered by Cognero®. Sign up or sign in at www.cengage.com to search for and access this product and its online resources.

About the Authors

Daniel Sandefur is a licensed electrical contractor, certified master electrical inspector, author, instructor, and consultant. Daniel began his electrical career wiring medium-voltage switchgear and substation breakers for Square D in Smyrna, Tennessee. He worked his way up to quality control and eventually became an electrical inspector for the state of Tennessee. In 2009, Daniel moved to central Florida to take a position with the Reedy Creek Improvement District as an electrical inspector and plans examiner for the Walt Disney World Resort. He now works as a senior construction manager for AOA (#insideAOA) and provides electrical consulting services to the themed entertainment industry for clients such as Walt Disney World, Disneyland, Meow Wolf, Universal Studios, Coca-Cola, SpaceX, Virgin Galactic, and other companies.

Daniel is licensed as a master electrician and electrical contractor in more than 35 states. His experience gives him the insight needed to provide clear interpretations of the *National Electrical Code*® and solve complex issues that arise on electrical construction projects.

Since 1999, Daniel has also traveled the country teaching continuing education and exam preparation seminars for tens of thousands of electricians through his company Classes4contractors. His success as an instructor comes from his ability to use real-world examples to simplify the code requirements. Daniel met Charles Miller during one of these seminars many years ago, and they formed a friendship and mutual respect for each other that has lasted for decades.

Charles R. Miller owned and operated a successful commercial electrical contracting company (Lighthouse Electric Co., Inc.) in Nashville, Tennessee, for 18 years. Throughout those years, he prided himself on solving problems abandoned by less-skilled or less-dedicated technicians. In 1988, he began operating a second company, dedicated to electrical-related training and known as Lighthouse Educational Services. Mr. Miller teaches custom-tailored classes and seminars covering various aspects of the *National Electrical Code*® and NFPA 70E.

Many students have taken advantage of his extensive experience in electrical contracting; regulatory exams (current electrical codes); electrical-related business and law; and electrical safety–related work practices. Class and seminar attendees have included individuals employed by companies such as Ford, Textron, the Aerostructures Corporation, Aladdin Industries, Lorillard Tobacco Company, Smith & Wesson, McKee Foods, Lockheed Martin, and Goodyear; by academic institutions such as Tennessee State University, Vanderbilt University, and Purdue University; and by governmental agencies, including the National Aeronautics and Space Administration (NASA).

In 1999, Charles started writing and illustrating the "Code in Focus" column in *Electrical Contractor* magazine. His attention-to-detail illustrations and writing style make this one of the top, if not the top, read columns in the monthly magazine. Charles Miller started writing for NFPA in 2003. His titles include *Pocket Guide to Residential Electrical Installations, Pocket Guide to Commercial and Industrial Electrical Installations, NFPA's Electrical References, NFPA's Pocket Electrical References, Electrician's Exam Prep Manual,* and *Ugly's Electrical Safety and NFPA 70E.* Besides teaching, writing, and illustrating, Charles cohosted a home improvement radio talk show in Nashville for more than three years.

Charles Miller has dedicated over 5000 hours to making *Illustrated Guide to the National Electrical Code*® a reality. His unsurpassed attention to detail is evident on every page. Since this book's inception, every day's waking hours have been consumed with careful planning and execution of content and design. His unwavering commitment to quality, from the first page in Unit 1 to the last page in Unit 19, has produced a technically superior, quintessentially user-friendly guide.

Acknowledgments

I would like to say "thank you" to my children, Christin and Adam, for being patient and understanding during the extremely long hours and endless days working on this text. My mother, Evelyn Miller, gets a special "thank you" and "I love you" for a lifetime of support and encouragement. She called every day to check on me and quite often sent encouraging greeting cards that always came at just the right time. "Thank you" to my wife, Linda, for all your love and support as I spent long hours writing and illustrating.

I also would like to thank the entire Cengage project team, comprising all those listed on the copyright page at the front of this book.

Last, but not least, the authors and Cengage would like to thank the following reviewers for their contributions:

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Electrical Program Instructor
Northeast Iowa Community College

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Section 1

Foundational Provisions

Unit 1

Introduction to the *National Electrical Code®*

Objectives

After studying this unit, the student should be able to:

- relate a brief account of electricity in its infancy.
- identify the catalyst that brought about the *National Electric Code®* (*NEC*).
- explain how the *NEC* began and its purpose.
- explain how changes to the *Code* evolve.
- summarize the terminology, presentation, and format of the *NEC*.
- explain what type of information is found in the *NEC* (its layout).
- explain why the *NEC* is concerned with equipment and material standards.
- identify various trademark logos that denote listed and labeled products.
- describe role of nationally recognized testing laboratories (NRTL) and the National Electrical Manufacturers Association (NEMA) as well as the expanded role of the National Fire Protection Association (NFPA).
- explain this book's layout, text conventions, and illustration methods.
- describe how to study the *Illustrated Guide to the NEC*.
- recall that electrical requirements in addition to the *NEC* may exist, and if so, that compliance is required.

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The *National Electrical Code*

Just as an extensive education is required for doctors to perform the duties of their chosen field, a working knowledge of the *NEC* is a necessity for anyone practicing a profession in the electrical industry. The *NEC* provides the standards by which all electrical installations are judged. Although other requirements, such as local ordinances and manufacturer instructions, must be applied, the *NEC* is the foundation on which successful installations are built. It is the most widely recognized and used compilation of technical rules for the installation and operation of electrical systems in the world today. Because of its widespread effect on the industry, it is important to understand the history of the *NEC*.

The Beginning

In 1882, New York City was home to the first central-station electric generating plant developed by Thomas A. Edison. The Pearl Street Station began operation at 3:00 P.M. on Monday, September 4. Fifty-nine customers had reluctantly consented to have their houses wired on the promise of three free months of electric light. They were given the option of discarding the service if it proved to be unsatisfactory. But this new way of lighting was more than satisfactory . . . it was a sensation. The number of customers tripled in only four months. And, as they say, the rest is history. The new industry swept the nation: New construction included the installation of electricity, and property owners demanded that existing structures be updated as well. New materials and equipment were developed and manufactured, and methods for installing and connecting these items to the electrical source were devised. For more than a decade, manufacturers, architects, engineers, inventors, electricians, and others worked independently to develop their contributions to the new technology. By 1895, there were as many as five different electric installation codes in use, and no single set of codes was accepted by all. To further complicate matters, there was an unexpected hazard darkening the prospects of this new industry.

Purpose and History of the *NEC*

Electrically caused fires were becoming commonplace and, by 1897, the problem was reaching epidemic proportions. A diverse group of knowledgeable, concerned individuals assembled to address this critical issue. The need for standardization was apparent. The consensus of more than 1200 individuals produced the first set of nationally adopted rules to govern electrical installations and operations—the *National Electrical Code.* The original Code document was developed as a result of the united efforts of various insurance, electrical, architectural, and allied interests.

The *NEC* states its purpose as . . . *the practical safeguarding of persons and property from hazards arising from the use of electricity.* This objective has remained constant throughout the *NEC*'s existence, and the principles it contains continue to grow and change with the dynamic electrical industry.

Code Changes

The *NEC* is regularly revised to reflect the evolution of products, materials, and installation techniques. Since 1911, the National Fire Protection Association (NFPA) of Quincy, Massachusetts, has been responsible for the maintenance and publication of the *NEC*. NFPA is responsible for the maintenance and publication of over three-hundred codes, standards, recommended practices, and guides. The 2023 edition, which contains hundreds of reworded, as well as new, regulations, represents the diligent work of eighteen code-making panels and the technical correlating committee, composed strictly of volunteers from all professions within the electrical industry. The *National Electrical Code* has been revised every three years since 1975.

These panels are complemented by a host of private individuals who submit proposals or comment on proposals already submitted for changes to the *NEC*. Anyone who wishes to participate can contact the National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471, and request a free booklet, "The NFPA Standards-Making System." The current edition of the *NEC* provides information in the back of the book for submitting public inputs and public comments for changes to the next edition, a copy of which is reproduced on the next page for your reference.

Now let us examine what is inside the *NEC* and how we can go about understanding it.

Submitting Public Input/Public Comment Through the Online Submission System

Following publication of the current edition of an NFPA standard, the development of the next edition begins and the standard is open for Public Input.

Submit a Public Input

NFPA accepts Public Input on documents through our online submission system at www.nfpa.org. To use the online submission system:

- Choose a document from the List of NFPA codes & standards or filter by Development Stage for "codes accepting public input."
- Once you are on the document page, select the "Next Edition" tab.
- Choose the link "The next edition of this standard is now open for Public Input." You will be asked to sign in or create a free online account with NFPA before using this system.
- Follow the online instructions to submit your Public Input (see www.nfpa.org/publicinput for detailed instructions).
- Once a Public Input is saved or submitted in the system, it can be located on the "My Profile" page by selecting the "My Public Inputs/Comments/NITMAMs" section.

Submit a Public Comment

Once the First Draft Report becomes available there is a Public Comment period. Any objections or further related changes to the content of the First Draft must be submitted at the Comment Stage. To submit a Public Comment follow the same steps as previously explained for the submission of Public Input.

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NEC Terminology, Presentation, and Format

Tables present a requirement's multiple application possibilities.

Table 210.21(B)(3) Receptacle Ratings for Various Size Circuits

Circuit Rating (Amperes)	Receptacle Rating (Amperes)
15	15
20	15 or 20
30	30
40	40 or 50
50	50

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Diagrams, or figures, are used to further clarify *NEC* applications.

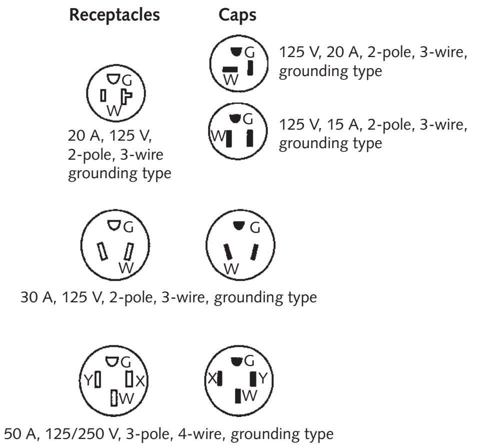
Receptacles
Caps
G
W
125 V, 20 A, 2-pole, 3-wire, grounding type
125 V, 15 A, 2-pole, 3-wire, grounding type
20 A, 125 V, 2-pole, 3-wire grounding type
30 A, 125 V, 2-pole, 3-wire, grounding type
X
Y
50 A, 125/250 V, 3-pole, 4-wire, grounding type

Figure 551.46(C)(1) Configurations for grounding-type receptacles and attachment plug caps used for recreational vehicle supply cords and recreational vehicle lots.

Formal Interpretations

Section 90.6 states: *To promote uniformity of interpretation and application of this Code, formal interpretation procedures have been established and are found in the Regulations Governing the Development of NFPA Standards.* (Contact NFPA for a copy of this annual publication.)

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Dictionary-style header—The left header shows the first section referenced, and the right header shows the last section referenced.

Informational Notes contain explanatory material such as references to other standards, references to related sections of the *Code*, or information related to a *Code* rule. These are informational only and do not require compliance »*90.5(C)*«.

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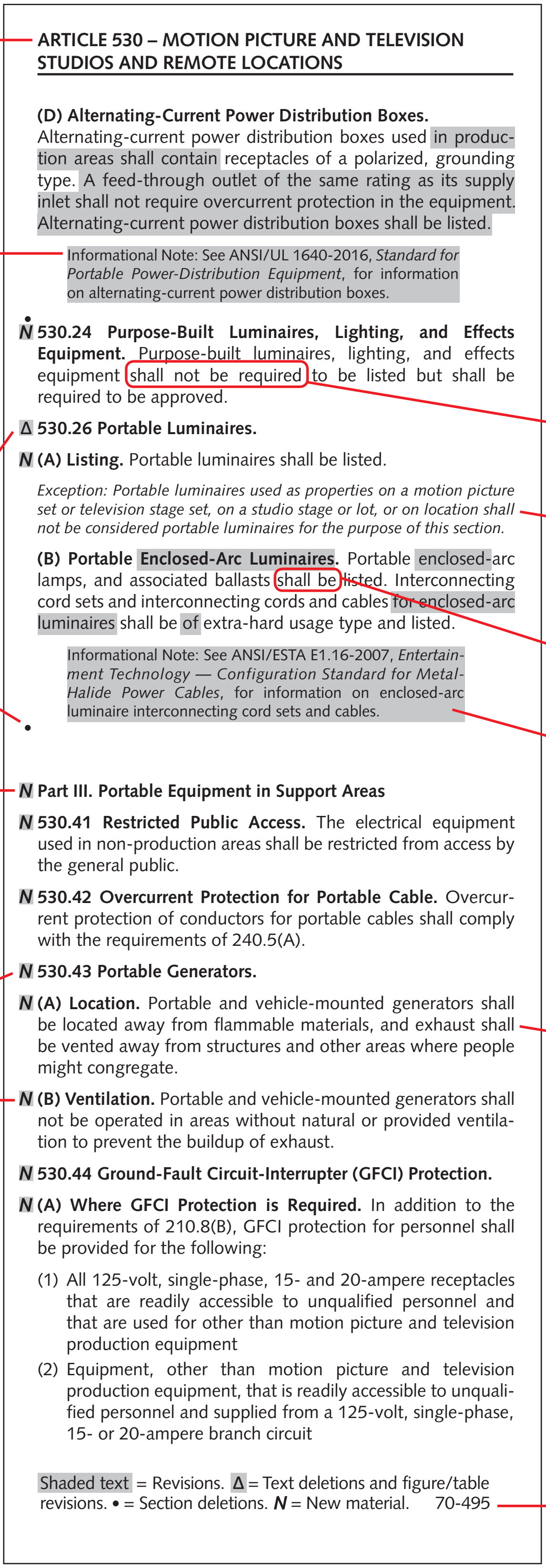
Parts (subheadings) are used to break down articles into simpler topics. (Not all articles have subheadings.)

Sections are numerical listings where the *Code* requirements are located.

N This icon indicates new sections or new articles. These sections could be new or just moved from other sections.



ARTICLE 530 – MOTION PICTURE AND TELEVISION STUDIOS AND REMOTE LOCATIONS

(D) Alternating-Current Power Distribution Boxes. Alternating-current power distribution boxes used in production areas shall contain receptacles of a polarized, grounding type. A feed-through outlet of the same rating as its supply inlet shall not require overcurrent protection in the equipment. Alternating-current power distribution boxes shall be listed.

Informational Note: See ANSI/UL 1640-2016, *Standard for Portable Power-Distribution Equipment*, for information on alternating-current power distribution boxes.

•

N **530.24 Purpose-Built Luminaires, Lighting, and Effects Equipment.** Purpose-built luminaires, lighting, and effects equipment shall not be required to be listed but shall be required to be approved.

Δ **530.26 Portable Luminaires.**

N **(A) Listing.** Portable luminaires shall be listed.

Exception: Portable luminaires used as properties on a motion picture set or television stage set, on a studio stage or lot, or on location shall not be considered portable luminaires for the purpose of this section.

(B) Portable Enclosed-Arc Luminaires. Portable enclosed-arc lamps, and associated ballasts shall be listed. Interconnecting cord sets and interconnecting cords and cables for enclosed-arc luminaires shall be of extra-hard usage type and listed.

Informational Note: See ANSI/ESTA E1.16-2007, *Entertainment Technology — Configuration Standard for Metal-Halide Power Cables*, for information on enclosed-arc luminaire interconnecting cord sets and cables.

•

N **Part III. Portable Equipment in Support Areas**

N **530.41 Restricted Public Access.** The electrical equipment used in non-production areas shall be restricted from access by the general public.

N **530.42 Overcurrent Protection for Portable Cable.** Overcurrent protection of conductors for portable cables shall comply with the requirements of 240.5(A).

N **530.43 Portable Generators.**

N **(A) Location.** Portable and vehicle-mounted generators shall be located away from flammable materials, and exhaust shall be vented away from structures and other areas where people might congregate.

N **(B) Ventilation.** Portable and vehicle-mounted generators shall not be operated in areas without natural or provided ventilation to prevent the buildup of exhaust.

N **530.44 Ground-Fault Circuit-Interrupter (GFCI) Protection.**

N **(A) Where GFCI Protection is Required.** In addition to the requirements of 210.8(B), GFCI protection for personnel shall be provided for the following:

(1) All 125-volt, single-phase, 15- and 20-ampere receptacles that are readily accessible to unqualified personnel and that are used for other than motion picture and television production equipment

(2) Equipment, other than motion picture and television production equipment, that is readily accessible to unqualified personnel and supplied from a 125-volt, single-phase, 15- or 20-ampere branch circuit

Shaded text = Revisions. Δ = Text deletions and figure/table revisions. • = Section deletions. ***N*** = New material. 70-495

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Caution

Be advised that the local authority having jurisdiction has the ability to amend the *Code* requirements. Consult the proper authority to obtain applicable guidelines.

Permissive rules contain the phrases "shall be permitted" or "shall not be required." These phrases normally describe options or alternative methods. Compliance is discretionary »*90.5(B)*«.

Exceptions appear in *italics* and explain when and where a specific rule does not apply.

Mandatory rules use the terms "shall" or "shall not" and require compliance »*90.5(A)*«.

Highlighted text within sections indicates changes, other than editorial, since the last *NEC* edition. The letter N with gray shading is placed in outside margins to identify new sections and for new articles.

Normal black letters are used for basic *Code* rules, definitions, and explanations.

NFPA document number followed by a page number.

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The *NEC* Layout

The table of contents in the *NEC* provides a breakdown of the information found in the book. Chapters 1 through 4 contain the most-often used articles in the *Code,* because they include general, or basic, provisions. Chapter 1, while relatively brief, includes definitions essential to the proper application of the *NEC*. It also includes an introduction and a variety of general requirements for electrical installations. More general requirements are found in Chapters 2, 3, and 4, addressing Wiring and Protection, Wiring Methods and Materials, and Equipment for General Use. Chapters 1 through 4 apply generally to all electrical installations.

Chapter 1 – General

Chapter 2 – Wiring and Protection

Chapter 3 – Wiring Methods and Materials

Chapter 4 – Equipment for General Use

Special issues are covered in Chapters 5 through 7. Chapter 5 contains information on Special Occupancies; Chapter 6, Special Equipment; and Chapter 7, Special Conditions. The contents of these chapters supplement or modify the general rules found in the first four chapters, as well as the rules found in Chapters 5, 6, and 7.

Chapter 5 – Special Occupancies

Chapter 6 – Special Equipment

Chapter 7 – Special Conditions

Chapter 8 is not subject to the requirements of Chapters 1 through 7 unless the requirements are specifically referenced in Chapter 8.

Chapter 8 – Communications Systems

The final chapter, Chapter 9, contains tables and examples. Provisions in this chapter are applicable as referenced. Each chapter contains one or more articles, and each article contains sections. Sections may be further subdivided by the use of lettered or numbered paragraphs.

Chapter 9 – Tables

Informative Annex A through Informative Annex J follow Chapter 9. Non-mandatory information relative to the use of the *NEC* is provided in the informative annexes. Because nothing in the annexes is enforceable as requirements in the *NEC*, the annexes are like Informational Notes. The *Code* is completed by an index.

Informative Annexes A through J

Wiring System Product Standards

In addition to installation rules, the *NEC* is concerned with the type and quality of electrical wiring system materials. Two terms are synonymous with acceptability in this area: **labeled** and **listed.** Their definitions, found in *Article 100*, are very similar. Similarities within these definitions include: (1) an organization that is responsible for providing the listing or labeling, (2) that these organizations must be acceptable to the authority having jurisdiction, (3) that both are concerned with the evaluation of products, and (4) that both maintain periodic inspection of the production (or manufacturing) of the equipment or materials which have been listed or labeled. A manufacturer of labeled equipment (or material) must continue to comply with the appropriate standards (or performance) under which the labeling was granted. "Listed" also means that the equipment, materials, or services meet appropriate designated standards or have been tested and found suitable for a specified purpose. This information is compiled and published by the organization. The Informational Note under "Listed" states that each organization may have different means for identifying listed equipment. In fact, some do not recognize equipment as listed unless it is also labeled. Listed or labeled equipment must be installed and used as instructed »*110.3(B)*«.

The organizations described in the following directly affect the *Code* as it relates to equipment and material acceptability and play a role in developing and maintaining the standards set forth in the *NEC*.

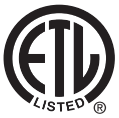
Nationally Recognized Testing Laboratories

Prior to 1989, there were only two organizations perceived as capable of providing safety certification of products that would be used nationwide. Because there were only two, innovative technology was slow to be tested and approved. When Congress created the Occupational Safety and Health Administration (OSHA) in the early 1970s, OSHA was directed to establish safety regulations for the workplace and for the monitoring of those regulations. OSHA adopted an explanation from the *NEC* and included it in the *Code of Federal Regulations.* In part, it reads: "an installation or equipment is acceptable to the Assistant Secretary of Labor . . . if it is acceptable or certified, or listed, or labeled, or otherwise determined to be safe by a nationally recognized testing laboratory . . ." Informative Annex A in the back of the *National Electrical Code* provides a list of product safety standards used for product listing where that listing is required by the *NEC*.

Testing by a nationally recognized testing laboratory (NRTL) was specified in the Code of Federal Regulations, but requirements for becoming an NRTL had not yet been identified. Although OSHA introduced "Accreditation of Testing Laboratories" in 1973, the process through which a laboratory would receive accreditation was still missing. Cooperative efforts produced the OSHA regulation finalized in 1988, and called "OSHA Recognition Process for Nationally Recognized Testing Laboratories."

OSHA's NRTL program greatly benefits manufacturers by providing a system that certifies that a product meets national safety standards. Just as important, the door was opened for a greater number of laboratories to provide certification, and manufacturers are now better able to meet the demands of today's highly competitive market.

The aim of NRTLs is to ensure that electrical products properly safeguard against reasonable, identifiable risks. An extensive network of field personnel conduct unannounced inspections at manufacturing facilities that use the laboratory's "seal of approval." Some of the better-known trademarks of testing laboratories are shown below:



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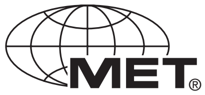
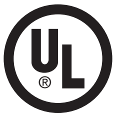
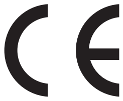


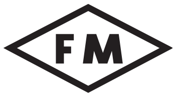
Source © MET Laboratories, Inc.



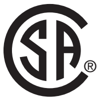
Source Underwriters Laboratories, Inc.



Source Antietam Compliance Company.



Source FM Global.



Source Interek.

Some of the labels that appear on evaluated and certified electrical products, such as the ones that follow, carry the trademarks of the testing laboratory or the laboratory's standards being used for comparison.

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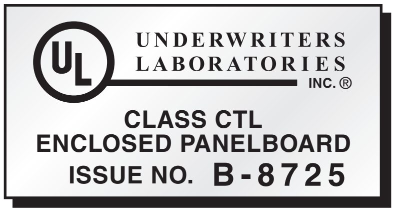
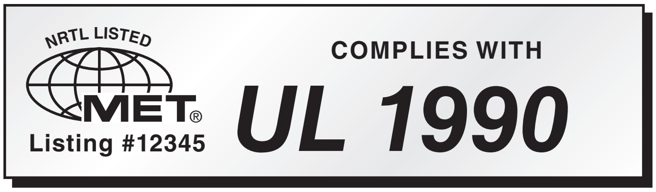
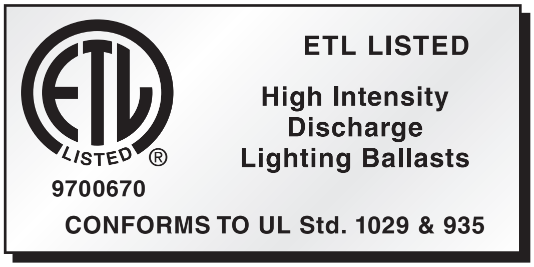

UL
UNDERWRITERS LABORATORIES INC.®
CLASS CTL
ENCLOSED PANELBOARD
ISSUE NO. B-8725

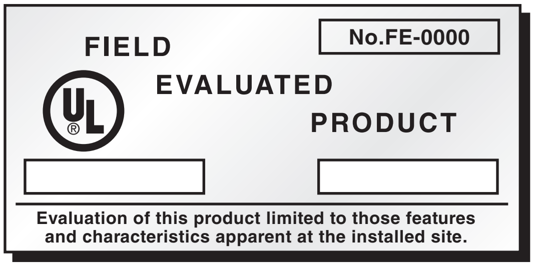
Source Underwriters Laboratories, LLC.


NRTL LISTED
MET®
Listing #12345
COMPLIES WITH
UL 1990

Source Underwriters Laboratories, LLC.


ETL
LISTED®
9700670
ETL LISTED
High Intensity
Discharge
Lighting Ballasts
CONFORMS TO UL Std. 1029 & 935

Source Interek.


FIELD
EVALUATED
PRODUCT
No.FE-0000
UL®
Evaluation of this product limited to those features and characteristics apparent at the installed site.

Source Underwriters Laboratories, LLC.

MET Laboratories

MET Laboratories, Inc., working with the Department of Labor as well as other agencies, served as a working example for the accreditation process for independent testing laboratories. In fact, MET became the first U.S. laboratory to successfully complete the process (1989), and thus became the first NRTL licensed by OSHA.

MET field inspectors interact with local electrical inspectors throughout the country to ensure product acceptance by all federal and state regulatory officials. The MET label is accepted by all 50 states, the federal government, and major retailers.

Underwriters Laboratories, Inc.

Prior to the formalization of NRTLs in 1989, electrical product standards were primarily written by Underwriters Laboratories, Inc. (UL), who also performed certification testing. Standards written by UL are still widely used. The appearance of the UL logo on a label indicates that the product complies with the UL standard. It does not mean, necessarily, that UL did the product testing. Although one of many NRTLs, Underwriters Laboratories is perhaps the most widely recognized and respected testing laboratory in operation today. Founded in 1894, UL is a not-for-profit corporation whose mission is to bring safer products to the marketplace and to serve the public through rigorous product safety testing. This organization offers a wide range of services, which include, but are not limited to, product listing, classification, component recognition, field certification, field engineering, facility registration, inspection, fact-finding, and research. As one can see from this list, UL plays a major role in guiding the safety of the electrical industry.

Intertek Testing Services

Select laboratories of Intertek Testing Services (ITS) have passed OSHA's stringent NRTL accreditation procedures and thereby have earned the right to issue product approvals and list products using the familiar ETL listed and CE marks. ITS has been conducting performance and reliability tests to nearly 200 safety standards applicable to workplace-related products since 1896. Intertek's comprehensive program includes testing, listing, labeling, and quarterly follow-up inspections. While recognized internationally by its many listed marks, the ETL listed mark is accepted throughout the United States, by all jurisdictions for electrical products, when denoting compliance with nationally recognized standards such as Wyle Laboratories (WL), International Electrotechnical Commission (IEC), UL, Canadian Standards Association (CSA), and FM Approvals (FM).

National Electrical Manufacturers Association

Founded in 1926, National Electrical Manufacturers Association (NEMA) comprises companies that manufacture equipment for all facets of electrical application, from generation through utilization. Its expansive objectives include product quality maintenance and improvement, safety standards for product manufacture and usage, and a variety of product standards, such as ratings and performance. NEMA contributes to the development of the *National Electrical Safety Code* as well as the *NEC*.

National Fire Protection Association

The NFPA, more than a century old, dedicates itself to safety standards, gathering statistical data, conducting research, providing crucial information on fire protection, prevention, and suppression methods, and much more. Boasting an internationally diverse membership of more than 75,000, this leading nonprofit organization publishes over 300 widely recognized consensus codes, standards, recommended practices, and guides including the *NEC*. Its primary pursuit is to protect lives and property from the often catastrophic hazards of fire.

This Resource

The *Illustrated Guide to the NEC* is designed to teach through visualization. If a picture is truly worth a thousand words, this resource should provide a more in-depth look at the *National Electrical Code* than can be found in any other single publication. Its highly detailed illustrations are complemented with concise, easy-to-understand written information. Not intended as a how-to resource, the *Illustrated Guide to the NEC* instead strives to translate difficult material into simpler, straightforward principles. Once the reader understands how the *Code* translates in a specific area, the same techniques can be applied throughout.

Its Layout

Not only is the presentation of material in this resource different from others on the market, but the organization of information also offers a new approach. After covering the fundamental provisions in the balance of Unit 1, we proceed to address code requirements by type of occupancy. Comprehensive information is given for one-family dwellings, multifamily dwellings, commercial locations, and special occupancies. To accomplish this task, information has been gathered logically from throughout the *Code* and concentrated in one section, under the appropriate occupancy. Each occupancy type is broken down into its finite components, and each component is thoroughly discussed and illustrated (see table of contents).

Text Conventions

General text is grouped in small areas surrounding an illustration. **Notes** provide additional information considered relevant to the point being discussed. **Cautions** indicate that particular care is needed during application. **Warnings** indicate potential danger and are intended to prevent misunderstanding of a given rule.

Terms *Luminaire* and *Lighting Fixture*

The word *luminaire* is the international term for *lighting fixture*. As defined in *Article 100*, a luminaire is a complete lighting unit consisting of a light source such as a lamp or lamps, together with the parts designed to position the light source and to connect it to the power supply. It may also include parts to protect the light source, ballast, or distribute the light. A lampholder itself is not a luminaire. Starting with the 2002 edition, *luminaire* became the main term and *fixture* or *lighting fixture* followed in parentheses. In the 2008 edition, *fixture* and *lighting fixture* were removed and do not follow the term *luminaire.* Throughout this text, *fixture* and *lighting fixture* have also been omitted.

Study Tips

As the title implies, frequent references are made to the *National Electrical Code*. Keep a copy of the latest edition of the *Code* close at hand. Any confusion about terminology not cleared up by the "Definitions" section of this text may be explained by consulting the *Code's Article 100—Definitions* section. Whenever direct references are made to the *Code,* benefits will be gained by taking the time to read the suggested article or section. The *Illustrated Guide to the NEC* is not intended, in any way, to replace the *Code.* Each unit's "Competency Test" requires a thorough understanding of related *NEC* subject matter. Use of this text alone is insufficient to successfully complete the test. It is, however, intended as an indispensable supplement to the *NEC.*

Note that when comparing calculations made by both the English and metric systems, slight differences will occur due to the conversion method used. These differences are not significant, and calculations for both systems are, therefore, valid.

Additional Electrical Requirements

Local Ordinances

The importance of local (state, city, etc.) electrical codes cannot be overemphasized. Local agencies can adopt the *NEC* exactly as written or can amend the *Code* by incorporating more or less stringent regulations. While the *NEC* represents the minimum standards for safety, some jurisdictions have additional restrictions. Obtain a copy of additional requirements (if any) for your area.

Engineers or architects who design electrical systems may also set requirements beyond the provisions of the *NEC.* For example, an engineer might require the installation of 20-ampere circuits in areas where the *NEC* allows 15-ampere circuits. Requirements from engineers or architects are found in additional documents, such as the following.

Plans and Specifications

If plans and specifications are provided for a project by knowledgeable engineers or architects, this information must be considered and, if need be, compared to the requirements set forth by the *NEC.* It is unlikely that the plans or specifications provided by competent professionals will conflict with or contradict the *Code.* Nonetheless, it is best to be diligent in applying the governing principles of the *NEC.*

Manufacturer Instructions

Equipment or material may include instructions from the manufacturer. In accordance with 110.3(B), these instructions must be followed. For example, baseboard heaters generally include installation instructions. The *NEC* does not prohibit the installation of receptacle outlets above baseboard heaters, but the manufacturer's instructions may prohibit the installation of its heater below receptacles.

Conclusion

While this unit briefly discusses the history of the *National Electrical Code*, it is not possible to do justice to the importance of the *Code* in a few short pages. With only a glimpse into its history and present-day supporting structure, this text moves on to the task of understanding the contents of the *Code.* The *Illustrated Guide to the NEC* presents visually stimulating information in an occupancy-organized, concise format. To begin the journey through the 2023 edition of the *National Electrical Code*, simply turn the page, read, look, and understand.

Unit 1 Competency Test

***NEC*® Reference**	**Answer**	
____________	____________	1. The National Fire Protection Association has acted as sponsor of the *National Electrical Code* since ____________.
____________	____________	2. Informative Annex ____________ provides a list of product safety standards used for product listing where that listing is required by the *NEC*.
____________	____________	3. Which chapters in the *NEC* apply generally to all installations?
____________	____________	4. Every three years, the *National Electrical Code* is revised, but the Code has only been on a three-year revision cycle since ____________.
____________	____________	5. The purpose of the *National Electrical Code* is the practical safeguarding of ____________ from hazards arising from the use of electricity.
____________	____________	6. The original Code document was developed ____________ in as a result of the united efforts of various insurance, electrical, architectural, and allied interests.
____________	____________	7. Informative annexes are not part of the requirements of the *NEC* but are included for ____________ only.
____________	____________	8. What city was home to the first central-station electric generating plant developed by Thomas A. Edison?
____________	____________	9. Chapter ____________ consists of tables that are applicable as referenced.
____________	____________	10. In the *NEC*, UL is the abbreviation for ____________.
____________	____________	11. Equipment that is listed, labeled, or both, or identified for a use shall be installed and used in accordance with any ____________ included in the listing, labeling, or identification.

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Unit 2

Section One: Foundational Provisions

Definitions

Objectives

After studying this unit, the student should be able to:

- explain the meaning of the term **accessible** (1) when applied to wiring methods and (2) when applied to equipment.
- identify accessible equipment that is not readily accessible.
- evaluate accurately a location as accessible, readily accessible, or not readily accessible.
- identify equipment classified as appliances.
- name the one required item and at least one other item that defines an area as a bathroom.
- list the five categories of branch circuits and their differences.
- distinguish the difference between the terms **enclosed** and **guarded**.
- determine whether a load is continuous or noncontinuous.
- explain the difference between branch-circuit conductors and feeder conductors.
- describe the differences between the terms associated with grounded and grounding.
- recall the maximum distance permitted for **within sight** situations.
- identify examples of damp, dry, and wet locations.
- determine which conductors are neutral conductors.
- explain the electrical vocabulary associated with the word **service**.
- clarify what constitutes a separately derived system.
- recall that the authority having jurisdiction (AHJ) could provide special permission, which is defined as **written consent**.

Introduction

What is the difference between accessible and readily accessible? Which is appropriate in a given application? When sizing a branch circuit or feeder, is the electrical load considered continuous or noncontinuous? What is the difference between a damp location and a wet location? For a motor disconnecting means to be considered within sight of the motor, what is the maximum distance?

These and many other questions can be accurately answered only through a thorough understanding of *National Electrical Code*® *(NEC)* terminology. Knowing the correct definition of words and phrases as found in Article 100 is crucial to installing a hazard-free electrical system. Article 100 contains only those definitions essential to the application of the Code. It does not include commonly defined general or technical terms from related codes and standards. Article 100 no longer contains Part 1: General; Part II: Over 1000 Volts, Nominal; and Part III: Hazardous (Classified) Locations. Before the 2023 edition of the Code, if a word or term was used in only one article, the definition of that word or term would be located in the xxx.2 section of that specific article. In the 2023 Code, all definitions are located in Article 100. An article number in parentheses following the definition indicates that the definition applies to just that one article.

Unlike the *NEC*, this resource will not cover all definitions in one location. Words and terms associated with special occupancies and equipment will be defined within the specific subject.

Definitions

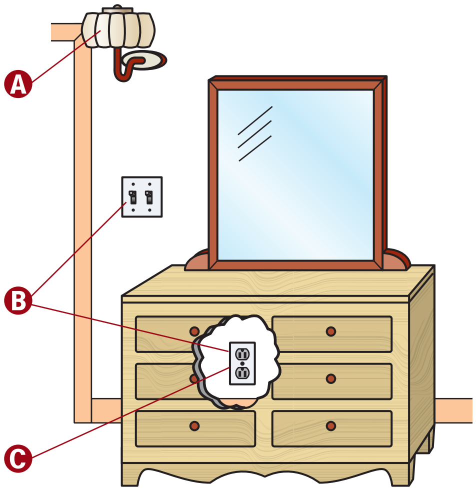
Accessible (As Applied to Wiring Methods)

Wiring components are considered accessible when (1) access can be gained without damaging the structure or finish of the building or (2) they are not permanently closed in or blocked by the structure, other electrical equipment, other building systems, or finish of the building »*Article 100*«.

A Conductors in junction boxes behind luminaires are considered accessible if, by removing the luminaire, access to the conductors is available.

B Boxes, conduit bodies, and handhole enclosures shall be installed so that the wiring contained in them can be rendered accessible »*314.29*«. Conductors connected to switches and receptacles are accessible by removing the cover-plate and device.

C Receptacles behind furniture are accessible because the furniture can be moved.



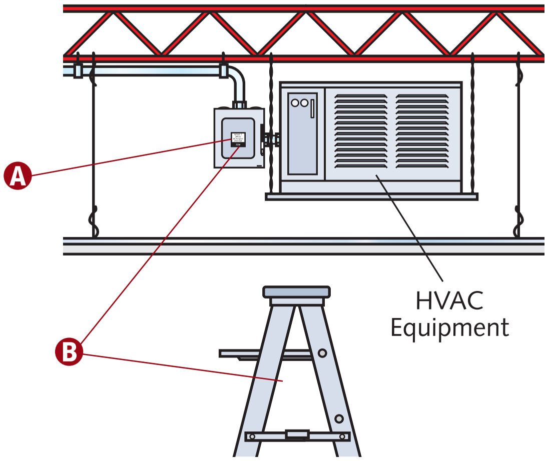
Note

Unlike readily accessible, wiring methods meet the definition of being accessible if access to the wiring method can be gained by using tools to remove covers or by climbing on ladders.

Accessible (As Applied to Equipment)

A **Accessible** equipment is equipment capable of being reached for operation, renewal, and inspection »*Article 100*«. Equipment installed in locations requiring the use of portable means, such as a ladder, is considered accessible, but not *readily* accessible.

B Overcurrent devices do not have to be **readily accessible** if located adjacent to the equipment where access is achieved by the use of portable means »*240.24(A)(4)*«.



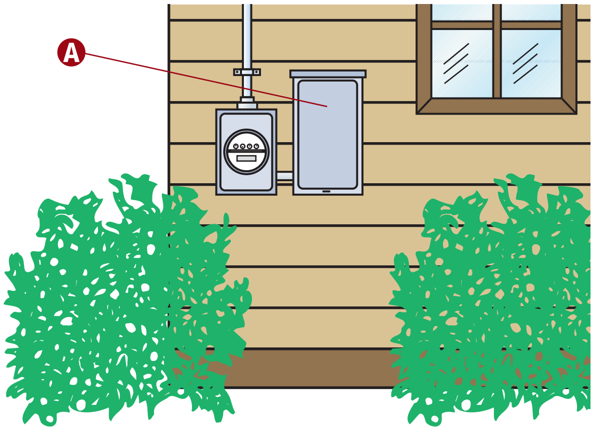
Accessible, Readily (Readily Accessible)

Readily accessible means capable of being reached quickly (for operation, renewal, or inspections) without having to take actions such as to use tools (other than keys), to climb over or under, to remove obstacles, or resort to portable ladders, etc. »*Article 100*«.

A The service disconnecting means must be readily accessible. It may be located either outside or inside, near the entry point of the service conductors »*230.70(A)(1)*«.

Note

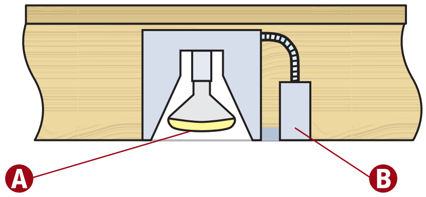
Use of keys is a common practice under controlled or supervised conditions and a common alternative to the ready access requirements under such supervised conditions as provided elsewhere in the *NEC*.
»Informational Note under Readily Accessible«



Accessible

A Ready accessibility to wiring in luminaires is not required. In most cases, access can be gained through the use of a ladder, scaffolding, etc.

B Conductors within junction boxes of recessed luminaires can be accessed by removing part of the luminaire, such as trims, lamps, internal shells, etc.



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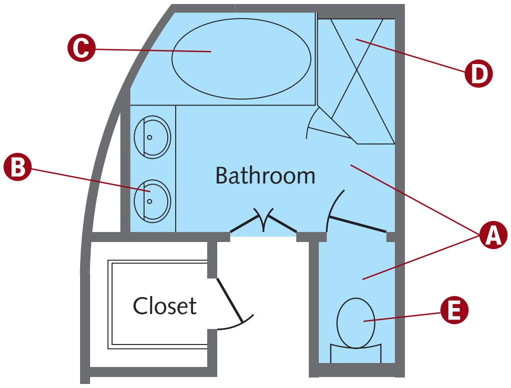
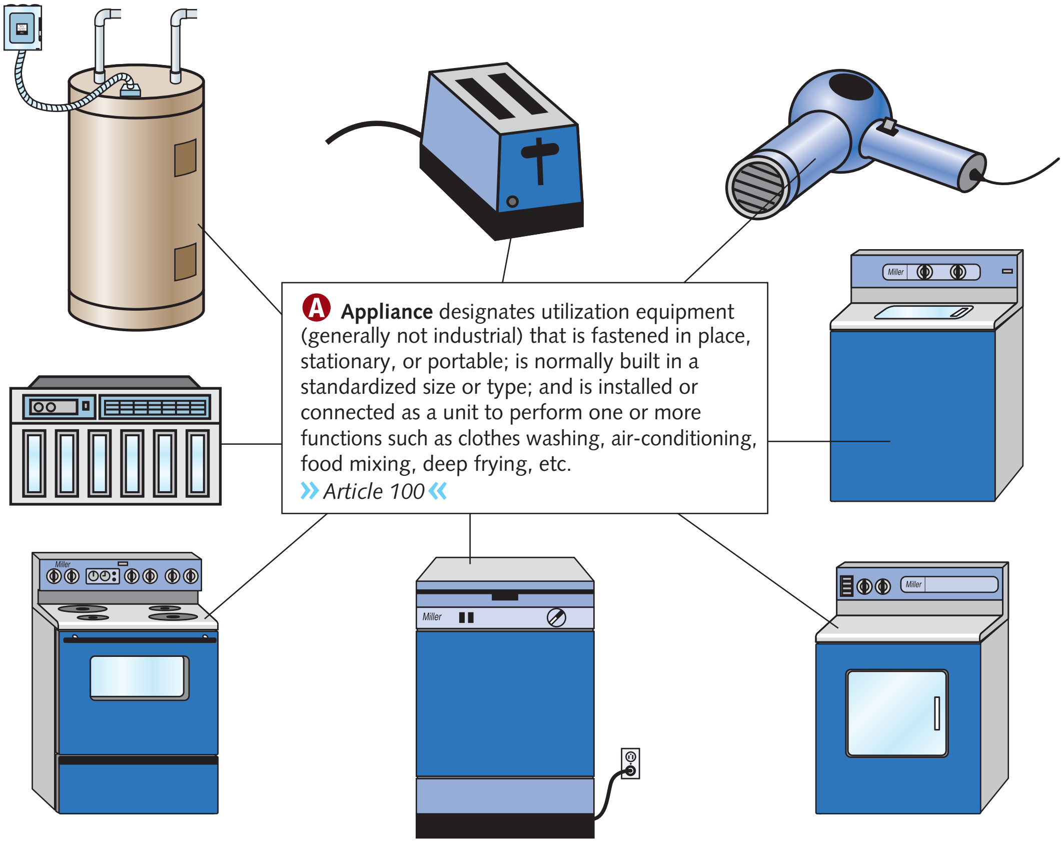
Bathroom

A bathroom is an area that includes a sink (basin) with one or more of the following: a toilet, a urinal, a tub, a shower, a bidet, or similar plumbing fixtures » *Article 100* «.

Ⓐ A bathroom is an area; it is not limited to a single room.
Ⓑ A bathroom includes at least one sink (basin).
Ⓒ An area having a sink and a tub is a bathroom.
Ⓓ An area having a sink and a shower is a bathroom.
Ⓔ An area having a sink and a toilet is a bathroom.



Appliance



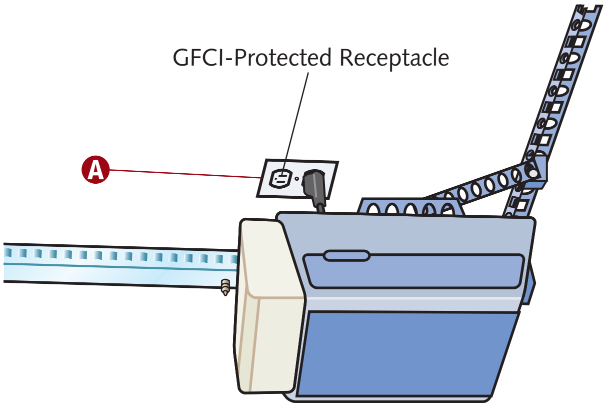
Ⓐ **Appliance** designates utilization equipment (generally not industrial) that is fastened in place, stationary, or portable; is normally built in a standardized size or type; and is installed or connected as a unit to perform one or more functions such as clothes washing, air-conditioning, food mixing, deep frying, etc. » *Article 100* «

Not Readily Accessible

Ⓐ While a ceiling receptacle installed for a garage door opener is not readily accessible, it is accessible. Even though this receptacle is not readily accessible, it must have ground-fault circuit-interrupter (GFCI) protection for personnel » *210.8(A)(2)* «.

Caution

The ground-fault circuit interrupter shall be installed in a readily accessible location » *210.8* «.



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Attachment Plug (Plug Cap) (Plug)

Ⓐ An attachment plug (plug cap) (plug) is a device that, when inserted into a receptacle, establishes connection between the conductors of the attached flexible cord and the conductors permanently connected to the receptacle »*Article 100*«.

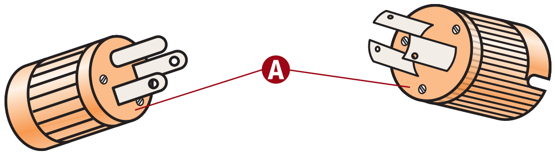
Arc-Fault Circuit Interrupter (AFCI)

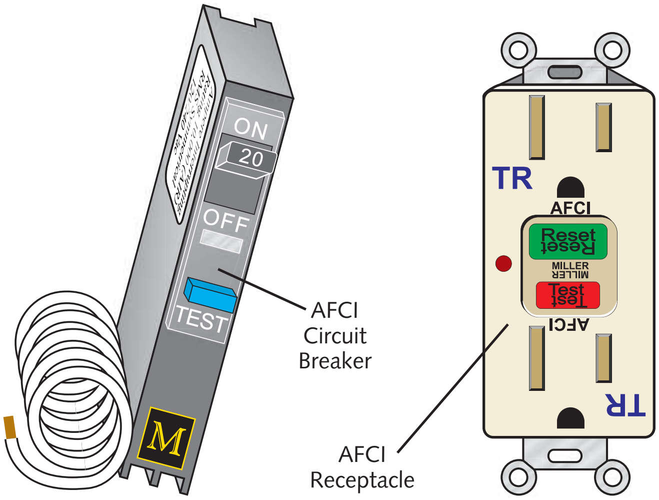
A device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected »*Article 100*«.

Bonding Conductor or Jumper, Supply-Side Bonding Jumper, and Main Bonding Jumper

Ⓐ When metal parts are required to be electrically connected, a reliable conductor (bonding jumper) is installed, thereby guaranteeing the required electrical conductivity »*Article 100*«.

Ⓑ A supply-side bonding jumper is a conductor installed on the supply side of a service or within a service equipment enclosure(s) that ensures the required electrical conductivity between metal parts required to be electrically connected. A supply-side bonding jumper is also a conductor installed for a separately derived system that ensures the required electrical conductivity between metal parts required to be electrically connected »*Article 100*«.

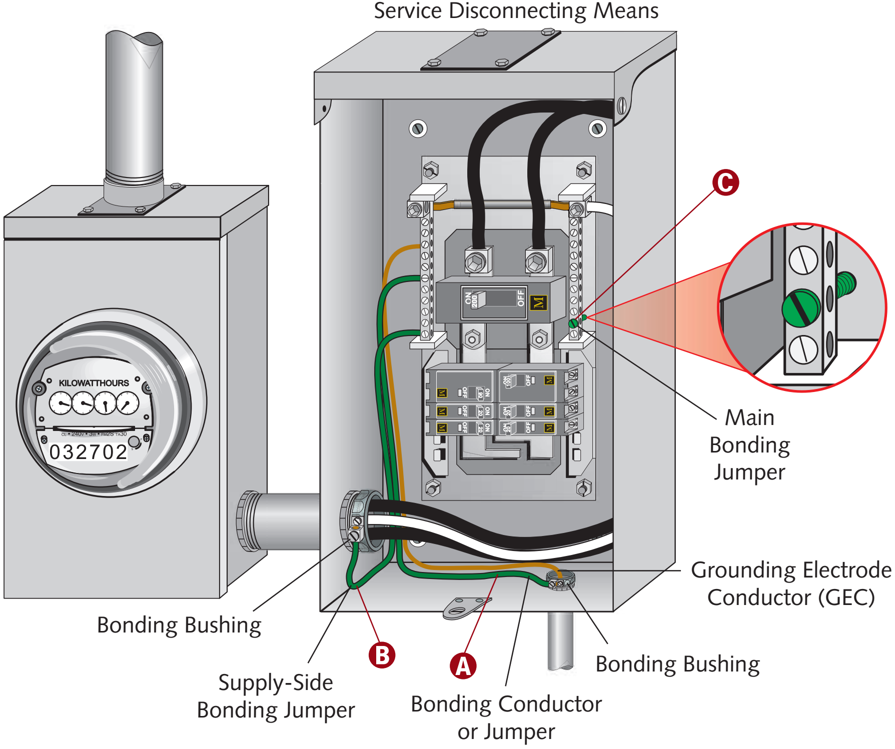



ON
20
OFF
TEST
M
AFCI Circuit Breaker
TR
AFCI
Reset
MILLER
Test
AFCI Receptacle

Ⓒ The main bonding jumper is the connection at the service between the grounded circuit conductor and the equipment grounding conductor or the supply-side bonding jumper, or both »*Article 100*«.

Note

Main bonding jumpers must be made of copper or other corrosion-resistant material. A wire, bus, screw, or similar suitable conductor is acceptable as a main bonding jumper ***»250.28(A)«***.


Service Disconnecting Means
KILOWATTHOURS
032702
C
Main Bonding Jumper
Grounding Electrode Conductor (GEC)
Bonding Bushing
Supply-Side Bonding Jumper
B
A
Bonding Conductor or Jumper
Bonding Bushing

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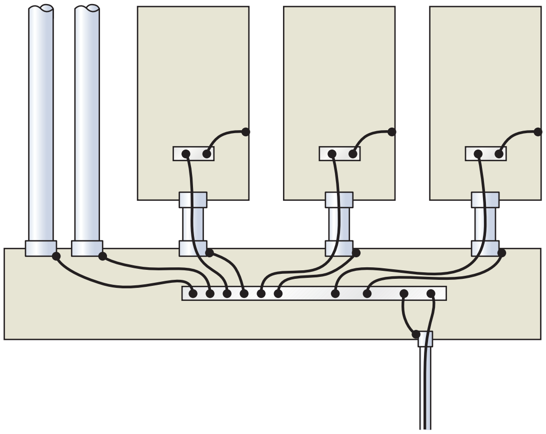
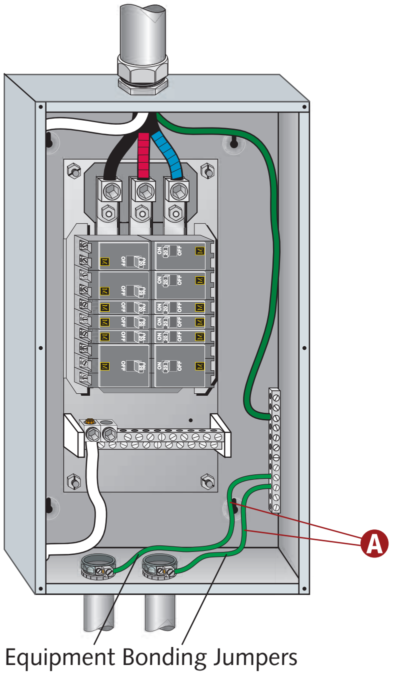
Bonded (Bonding)

Bonded is connected to establish electrical continuity and conductivity »*Article 100*«.



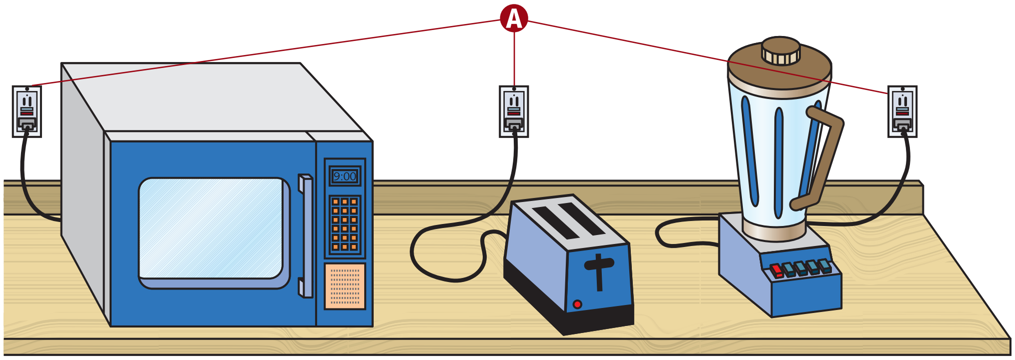
Bonding Jumper, Equipment

Ⓐ An equipment bonding jumper is the connection between two or more portions of the equipment grounding conductor »*Article 100*«.



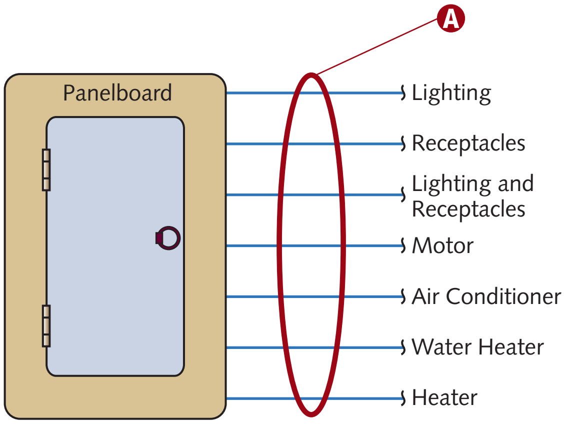
Branch Circuit, Appliance

Ⓐ An appliance branch circuit supplies energy to one or more outlets for the purpose of connecting appliance(s). These circuits exclude the connection of luminaires unless they are part of the appliance being connected »*Article 100*«.



Branch Circuit

Ⓐ The circuit conductors found between a circuit's final overcurrent protective device (such as the last fuse or circuit breaker) and the circuit's outlet(s) is called a branch circuit »*Article 100*«. Branch circuits are divided into five categories: appliance, general purpose, individual, motor, and multiwire.



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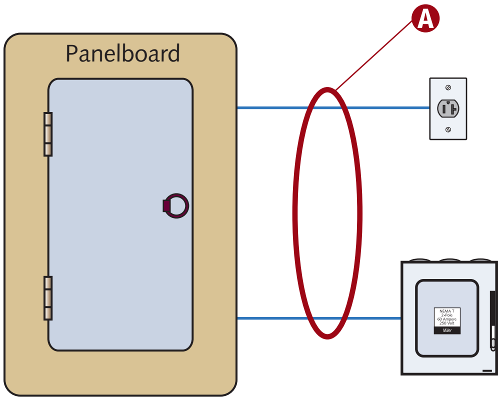
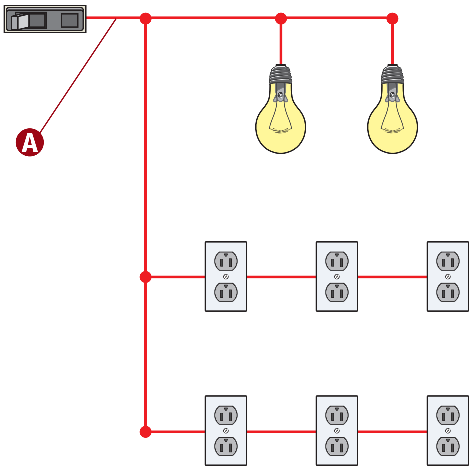
Branch Circuit, Individual

A An individual branch circuit supplies only one piece of utilization equipment »*Article 100*«.



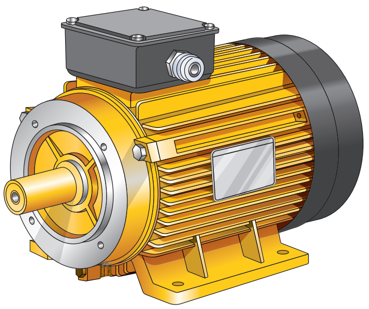
Branch Circuit, General Purpose

A A general purpose branch circuit supplies two or more receptacles or outlets for lighting and appliances »*Article 100*«.



Branch Circuit, Motor

A motor branch circuit includes the circuit conductors as well as the equipment between the motor branch-circuit short-circuit and ground-fault protective device and an individual motor »*Article 100*«.



Branch Circuit, Multiwire

A A voltmeter will not register a voltage (potential difference) when connected to the same ungrounded (hot) phase. Therefore, a multiwire circuit must consist of conductors connected to different phases.

B A multiwire branch circuit consists of two or more ungrounded (hot) conductors that have a voltage between them »*Article 100*«. Additionally, see **C** and **E**.

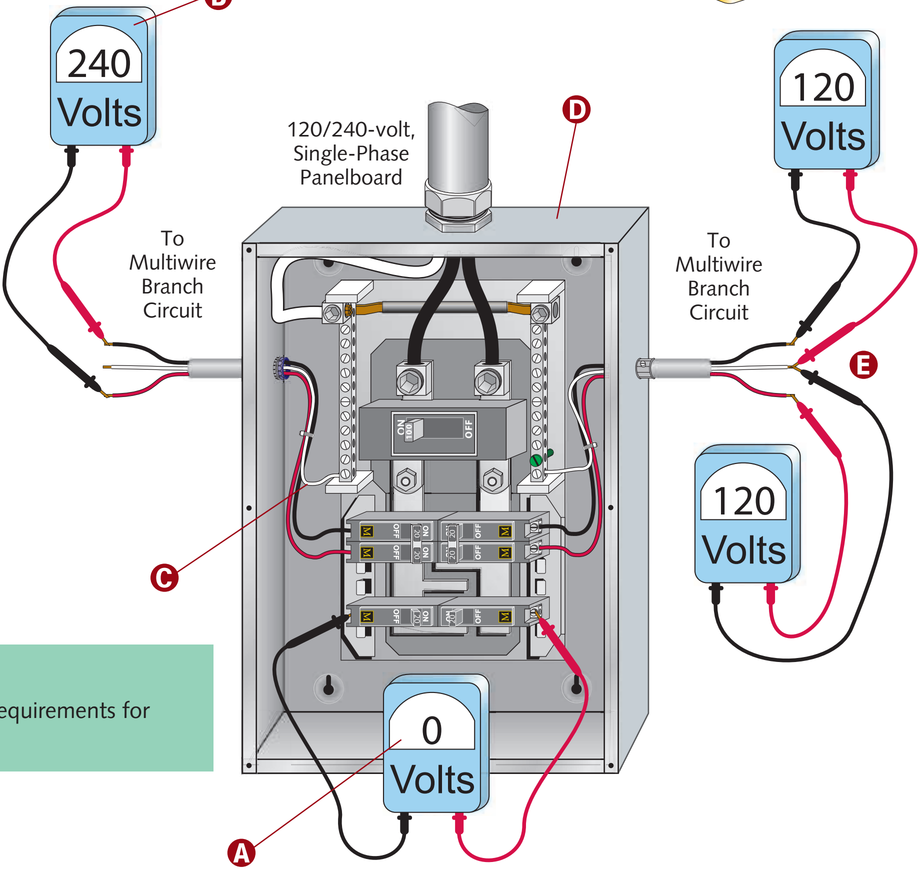
C The one grounded (neutral) conductor of a multiwire circuit must be connected to the neutral or grounded conductor of the system »*Article 100*«. Additionally, see **B** and **E**.

D All conductors of a multiwire branch circuit must originate from the same panelboard or similar distribution equipment »*210.4(A)*«.

E There must be only one grounded (neutral) conductor, and there must be an equal voltage between it and each ungrounded conductor of the circuit »*Article 100*«. Additionally, see **B** and **C**.

Note

See 210.4(A) through (D) for additional requirements for multiwire branch circuits.


B
240 Volts
120/240-volt, Single-Phase Panelboard
D
120 Volts
To Multiwire Branch Circuit
To Multiwire Branch Circuit
E
120 Volts
C
0 Volts
A

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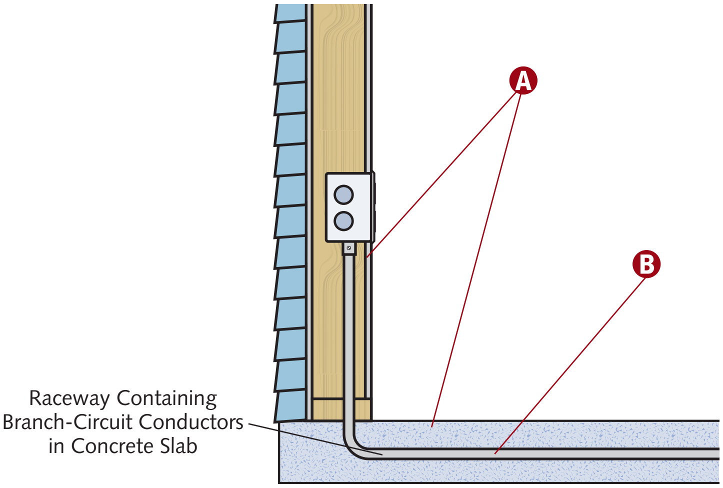
Concealed

A Concealed means rendered inaccessible by the structure or finish of the building »*Article 100*«.

B Conductors in concealed raceways, even though they may become accessible by withdrawing them, are still considered concealed »*Informational Note under Concealed*«.


A
B
Raceway Containing Branch-Circuit Conductors in Concrete Slab

Receptacles on Multiwire Branch Circuits

A multiwire receptacle circuit consists of one (or more) duplex receptacles, one (or more) multiple receptacles, two (or more) single receptacles, or combinations thereof.

A A duplex receptacle can be supplied by two branch circuits by removing the tab. This receptacle is fed from a multiwire branch circuit.

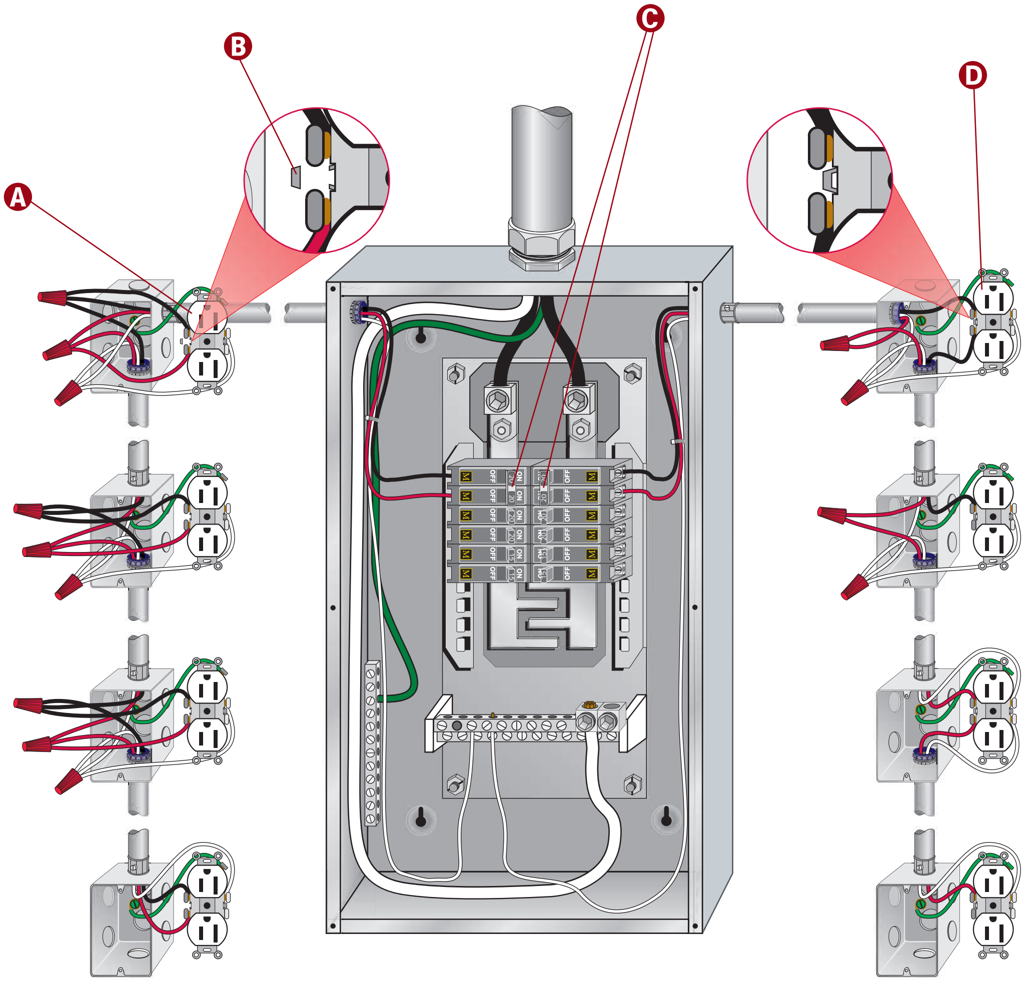
B The tab has been removed to allow separate feed of each outlet.

C Each multiwire branch circuit must be provided with a means that simultaneously disconnects all ungrounded (hot) conductors at the point where the branch circuit originates »*210.4(B)*«. This is accomplished through the use of either one double-pole breaker or two single-pole breakers with identified handle ties.

D Although the box contains a multiwire branch circuit, only one ungrounded (hot) conductor is feeding this duplex receptacle.

Warning

In multiwire branch circuits, the continuity of a grounded conductor shall not be dependent on the device »*300.13(B)*«. If breaking the grounded conductor at the receptacle breaks the circuit down the line, then the grounded conductors must not be connected to the receptacle. Simply splice the grounded conductors and install a jumper wire to the receptacle.



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Note

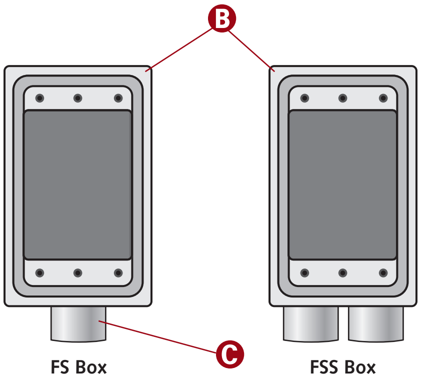
Switch-controlled split-wire duplex receptacle(s) are sometimes installed in lieu of a lighting outlet »*210.70(A)(1) Exception No. 1*«. One half of the duplex receptacle is controlled by a wall switch, while the other half is a typical receptacle. A split-wire receptacle receiving power from a single source (one breaker or one fuse) is not a multiwire receptacle.

Conduit Body

Ⓐ A conduit body is a separate portion of a conduit (or tubing) system providing access to the interior of the system through a removable cover(s) at a junction of multiple sections or at a terminal point of the system »*Article 100*«.

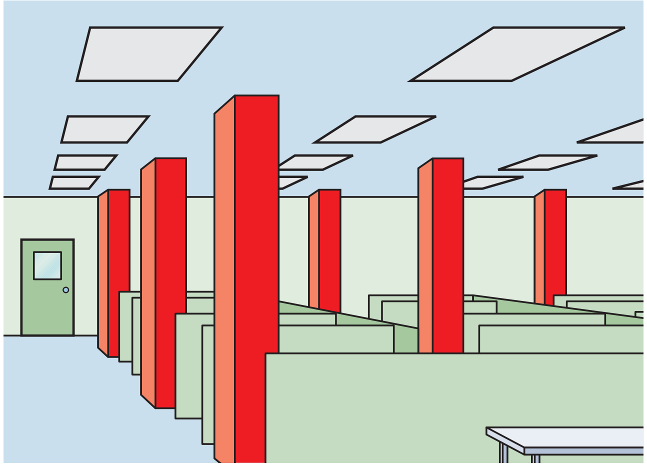
Ⓑ FS, FD, and larger boxes (cast or sheet metal) are not classified as conduit bodies »*Article 100*«.

Ⓒ A single conduit is not permitted as sole support for an FS-type or weatherproof junction box »*314.23(E)* and *314.23(F)*«.


B
C
FS Box
FSS Box

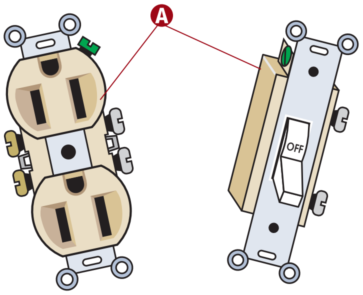
Continuous Load

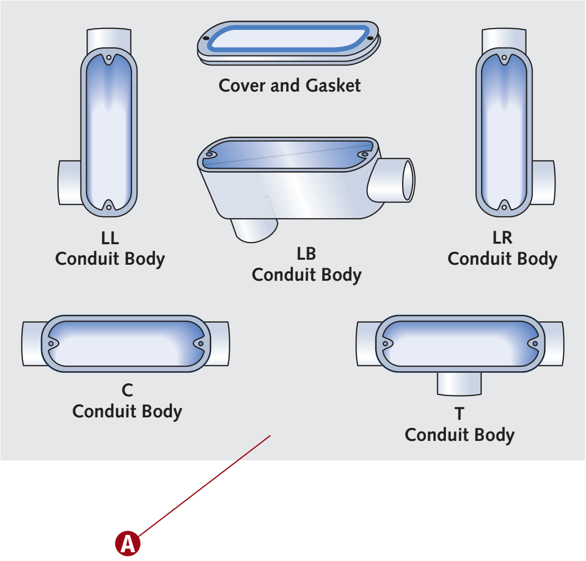
A load having the maximum level of current sustained for three hours or more is referred to as a continuous load »*Article 100*«. Office lighting is an example of a continuous load.



Device

Ⓐ A unit of an electrical system, other than a conductor, that carries or controls electrical energy as its principal function is known as a device »*Article 100*«.

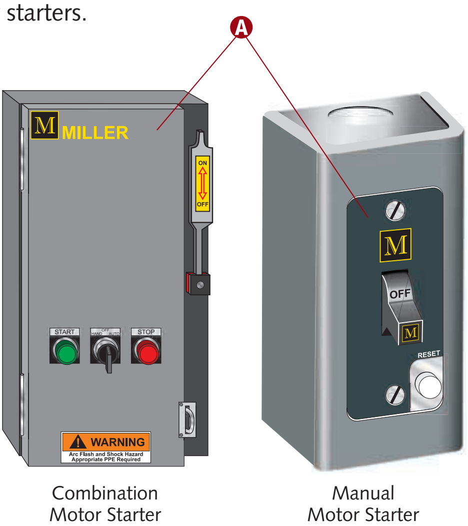



Cover and Gasket
LL Conduit Body
LB Conduit Body
LR Conduit Body
C Conduit Body
T Conduit Body
A

Controller

A controller is a device or group of devices that serves to govern, in some predetermined manner, the electric power delivered to the apparatus to which it is connected »*Article 100*«.

Ⓐ The *NEC* refers to these as controllers. Out in the field, these are called motor starters or starters.


A
M MILLER
ON
OFF
START
STOP
WARNING
Arc Flash and Shock Hazard
Appropriate PPE Required
M
OFF
M
RESET
Combination Motor Starter
Manual Motor Starter

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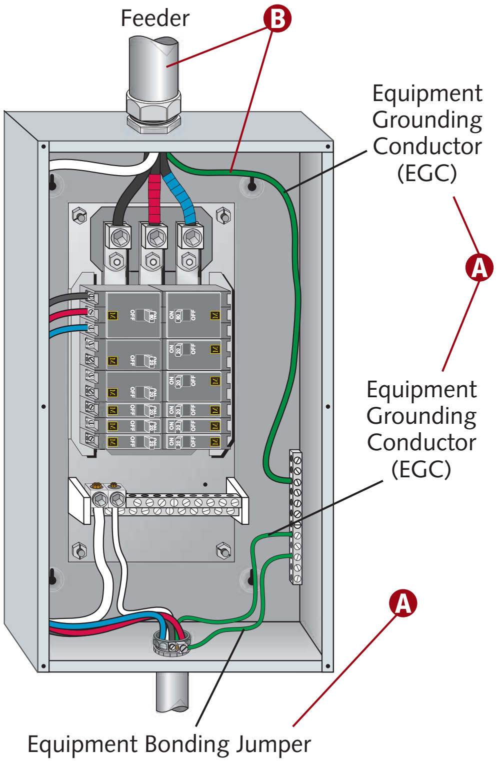
Effective Ground-Fault Current Path

A An effective ground-fault current path is an intentionally constructed, low-impedance electrically conductive path designed and intended to carry current during ground-fault events from the point of a ground fault on a wiring system to the electrical supply source. The reason for this intentionally constructed, low-impedance electrically conductive path is to facilitate the operation of the overcurrent protective device or ground-fault detector during a ground-fault event »*Article 100*«.

B A ground-fault current path is defined as an electrically conductive path from the point of a ground fault on a wiring system through normally non–current-carrying conductors, grounded conductors, equipment, or the earth to the electrical supply source. Examples of ground-fault current paths are any combination of equipment grounding conductors, metallic raceways, metallic cable sheaths, electrical equipment, and any other electrically conductive material such as metal, water, and gas piping; steel framing members; stucco mesh; metal ducting; reinforcing steel; shields of communications cables; and the earth itself »*Article 100*«.


Feeder
B
Equipment Grounding Conductor (EGC)
A
Equipment Grounding Conductor (EGC)
A
Equipment Bonding Jumper

Note

Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground-fault detector. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source. The earth shall not be considered as an effective ground-fault current path »***250.4(A)(5)***«.

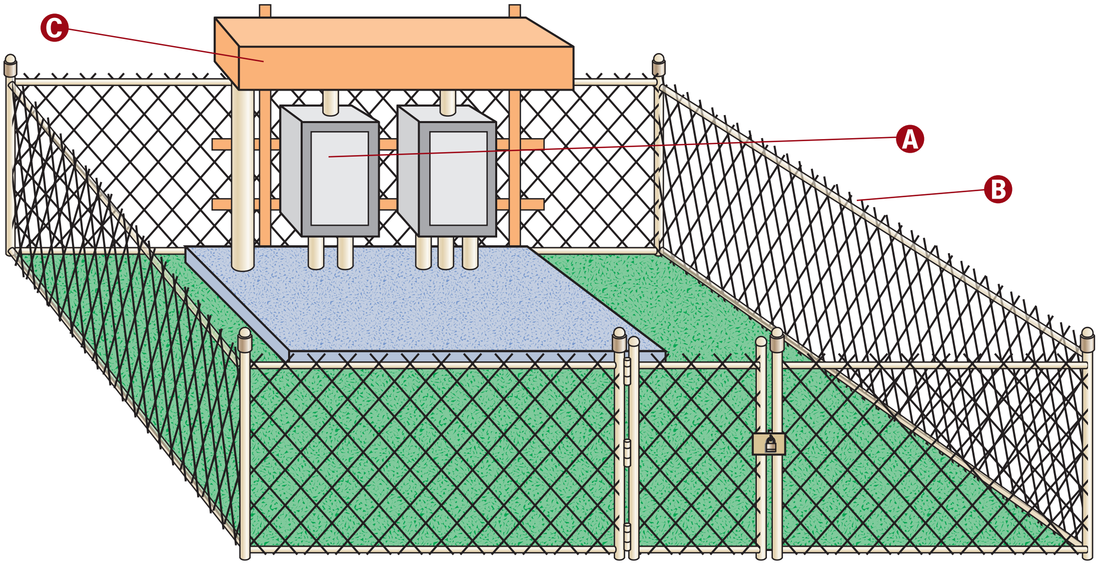
Enclosed

Equipment, conductors, etc., surrounded by a case, housing, fence, or walls that prevent persons from accidentally contacting energized parts are referred to as enclosed »*Article 100*«.

A Panelboards located within cabinets or cutout boxes are considered enclosed.

B Electrical equipment installed within the perimeter of a fence, or similar area, qualifies as enclosed.

C Conductors are also considered enclosed when installed in panels, wireways, raceways, etc.



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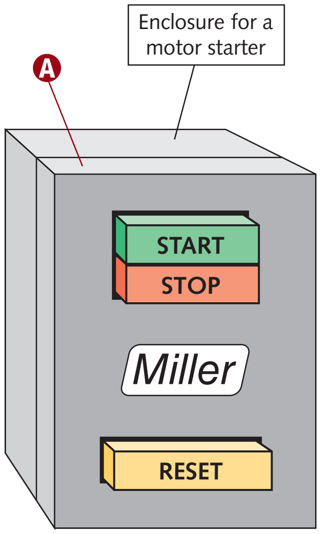
Enclosure

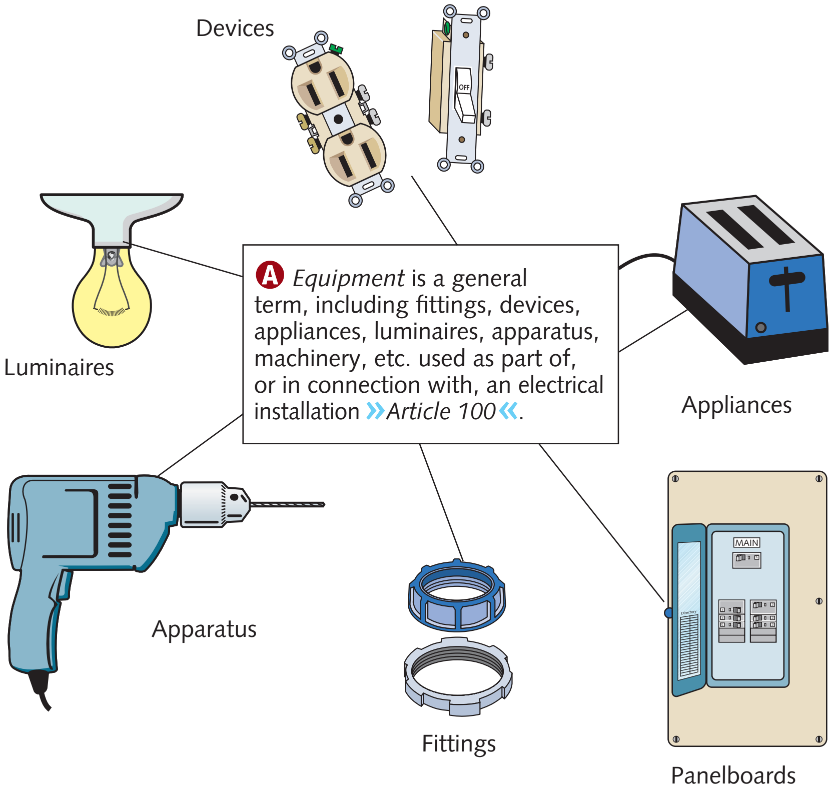
Ⓐ Any case, housing, apparatus, fence, or walls surrounding an installation, designed to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage, serves as an enclosure »*Article 100*«.

Note

See Table 110.28 in the *NEC* for examples of enclosure types.


Enclosure for a motor starter
Ⓐ
START
STOP
Miller
RESET

Equipment


Devices
Luminaires
Appliances
Apparatus
Fittings
Panelboards

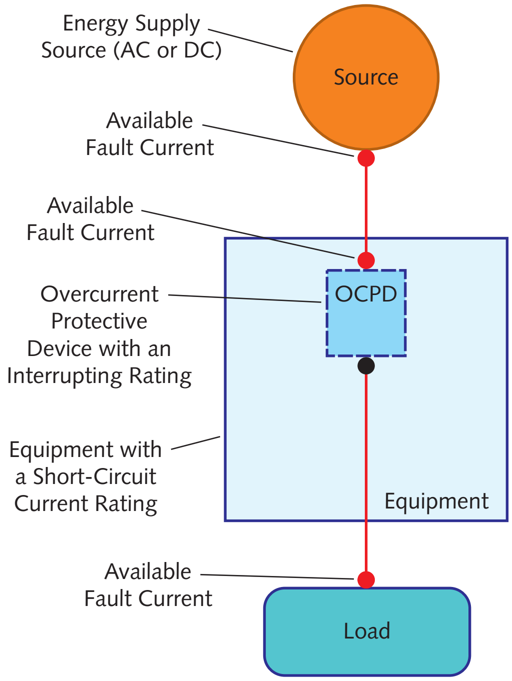
Ⓐ *Equipment* is a general term, including fittings, devices, appliances, luminaires, apparatus, machinery, etc. used as part of, or in connection with, an electrical installation »*Article 100*«.

Available Fault Current

Available fault current is the largest amount of current capable of being delivered at a point on the system during a short-circuit condition »*Article 100*«. A short-circuit can occur during abnormal conditions such as a fault between circuit conductors or a ground fault »*Informational Note under Available Fault Current*«.

Note

Fault current is the current delivered at a point on the system during a short-circuit condition »***Article 100***«.


Energy Supply Source (AC or DC)
Source
Available Fault Current
Available Fault Current
Overcurrent Protective Device with an Interrupting Rating
OCPD
Equipment with a Short-Circuit Current Rating
Equipment
Available Fault Current
Load

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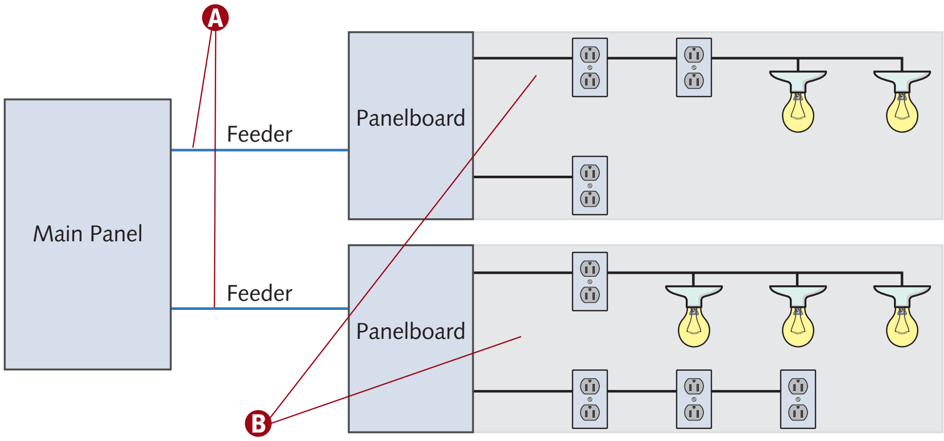
Feeder

A A feeder consists of all circuit conductors located between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device »*Article 100*«.

B Branch circuits (see definition).

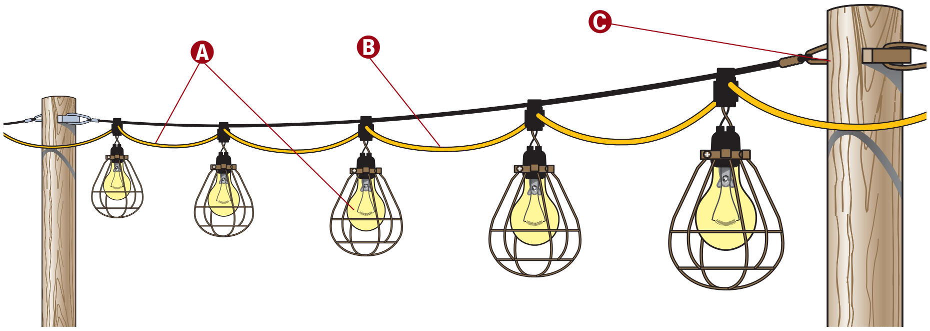

A
Feeder
Feeder
Main Panel
Panelboard
Panelboard
B

Festoon Lighting

A Festoon lighting is a string of outdoor lights suspended between two points »*Article 100*«.

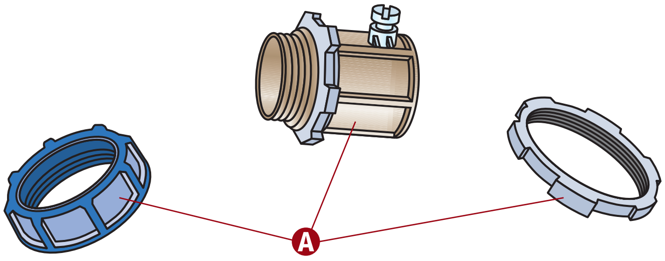
B Overhead conductors for festoon lighting shall not be smaller than 12 AWG unless supported by messenger wires »*225.6(B)*«.

C Messenger wire, together with strain insulators, shall be used to support conductors in all spans exceeding 40 ft (12 m) in length. Conductors shall not be attached to any fire escape, downspout, or plumbing equipment »*225.6(B)*«.



Fitting

A A fitting is an accessory such as a locknut, bushing, or other part of a wiring system whose function is primarily mechanical, rather than electrical, in nature »*Article 100*«.

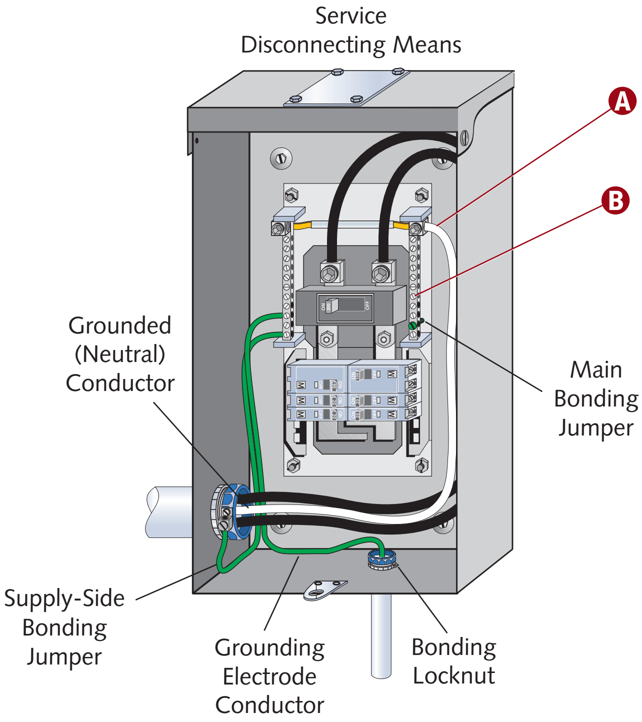


Grounded and Grounded Conductor

A A grounded conductor is a system or circuit conductor that is intentionally grounded »*Article 100*«.

B Grounded (grounding) is defined as being connected to ground or to a conductive body that extends the ground connection »*Article 100*«.

> **Note**
>
> Ground is defined as the earth »*Article 100*«.


Service Disconnecting Means
A
B
Grounded (Neutral) Conductor
Main Bonding Jumper
Supply-Side Bonding Jumper
Grounding Electrode Conductor
Bonding Locknut

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Grounding Electrode, Grounding Electrode Conductor, and Equipment Grounding Conductor (EGC)

A Main service equipment

B The conductive path(s) that is part of an effective ground-fault current path and connects normally non-current-carrying metal parts of equipment together and to the system grounded conductor, the grounding electrode conductor, or both is called an equipment grounding conductor »*Article 100*«.

C System grounded (neutral) conductor

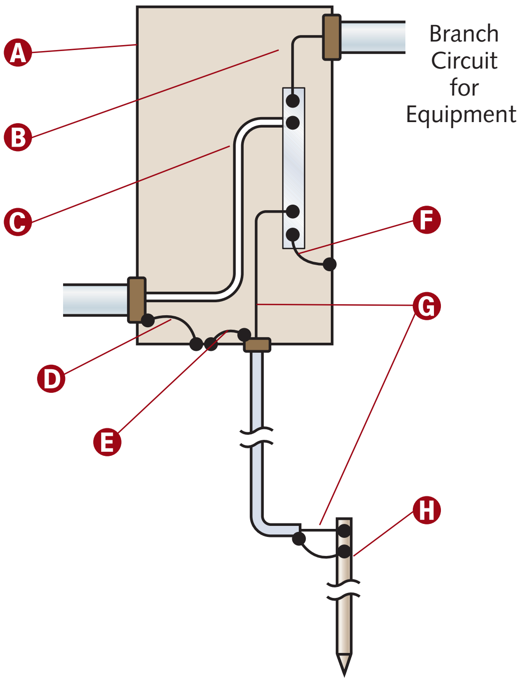
D Supply-side bonding jumper

E Bonding jumper or conductor

F Main bonding jumper

G The grounding electrode conductor is the conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system »*Article 100*«.

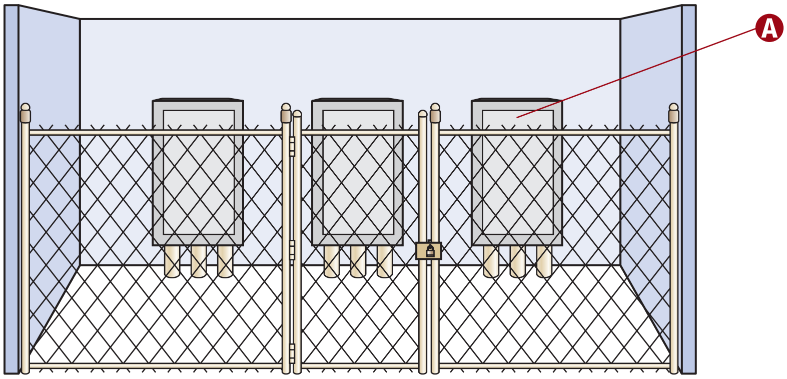
H A grounding electrode is a conducting object that establishes a direct connection to earth »*Article 100*«.



Guarded

Guarded is defined as covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms effectively removing the likelihood of approach or contact by persons or objects »*Article 100*«.

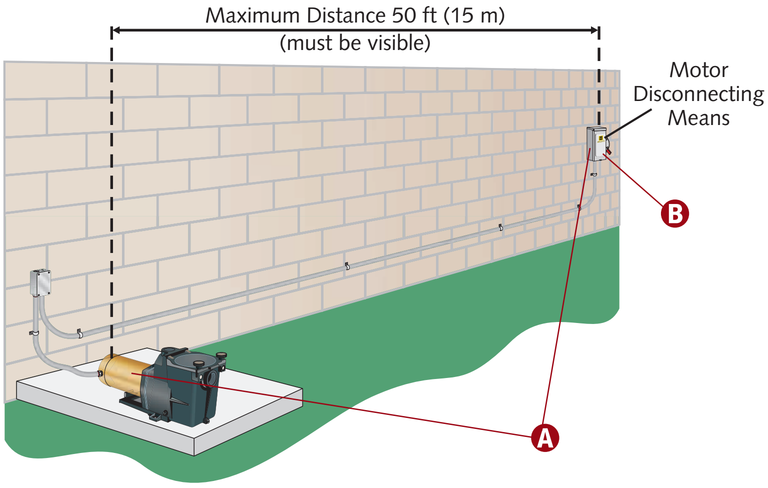
A Panelboards having doors or covers are considered guarded.



In Sight From (Within Sight From, Within Sight)

A The *NEC* terms *in sight from, within sight from, within sight*, etc., applied to equipment indicate that the specified items of equipment are visible and are not more than 50 ft (15 m) apart »*Article 100*«.

B A motor disconnecting means must be located in sight from the motor location as required by 430.102(B).



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Industrial Control Panel

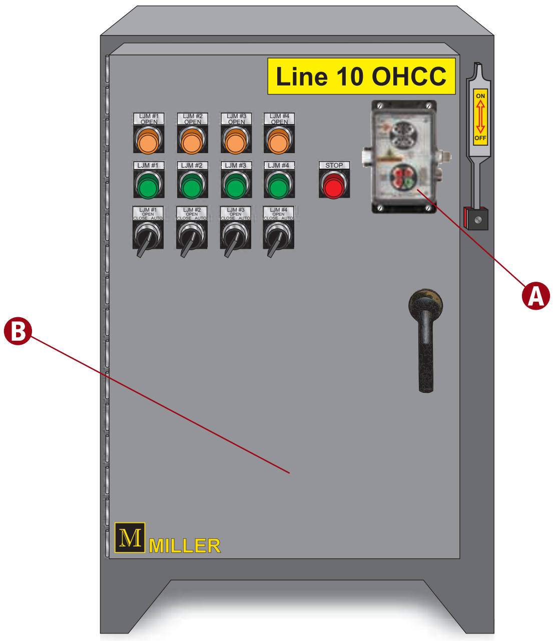
An industrial control panel is an assembly of two or more components consisting of one of the following: (1) power circuit components only, such as motor controllers, overload relays, fused disconnect switches, and circuit breakers; (2) control circuit components only, such as push buttons, pilot lights, selector switches, timers, switches, and control relays; and (3) a combination of power and control circuit components »*Article 100*«.

Ⓐ The power and control circuit components, with associated wiring and terminals, are mounted on, or contained within, an enclosure or mounted on a subpanel »*Article 100*«.

Ⓑ The industrial control panel does not include the controlled equipment »*Article 100*«.

Note

Requirements for industrial control panels are in Article 409. Article 409 covers industrial control panels intended for general use and operating at 1000 volts or less »***409.1***«.



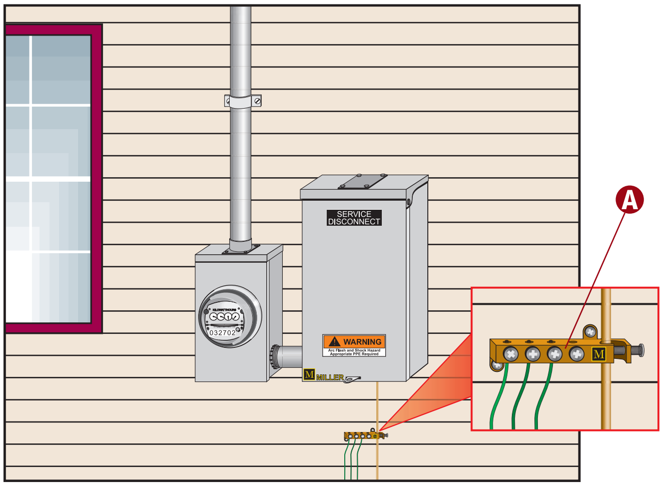
Industrial Control Panel

Intersystem Bonding Termination

Ⓐ An intersystem bonding termination is a device that provides a means for connecting intersystem bonding conductors for communications systems to the grounding electrode system »*Article 100*«.

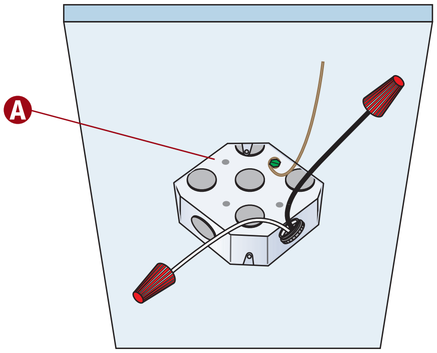
Note

For intersystem bonding termination requirements, see Unit 9 Services and Electrical Equipment.



Lighting Outlet

Ⓐ An outlet intended for the direct connection of a lampholder or luminaire is called a lighting outlet »*Article 100*«.



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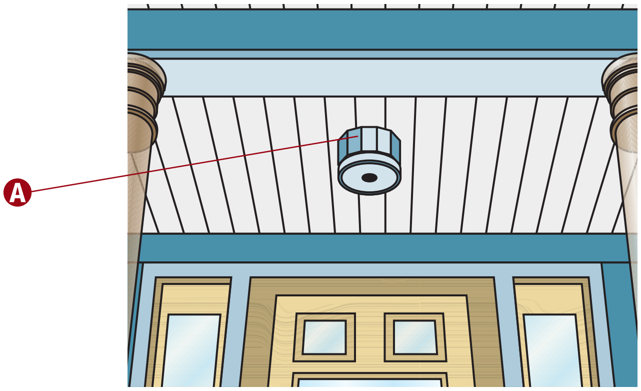
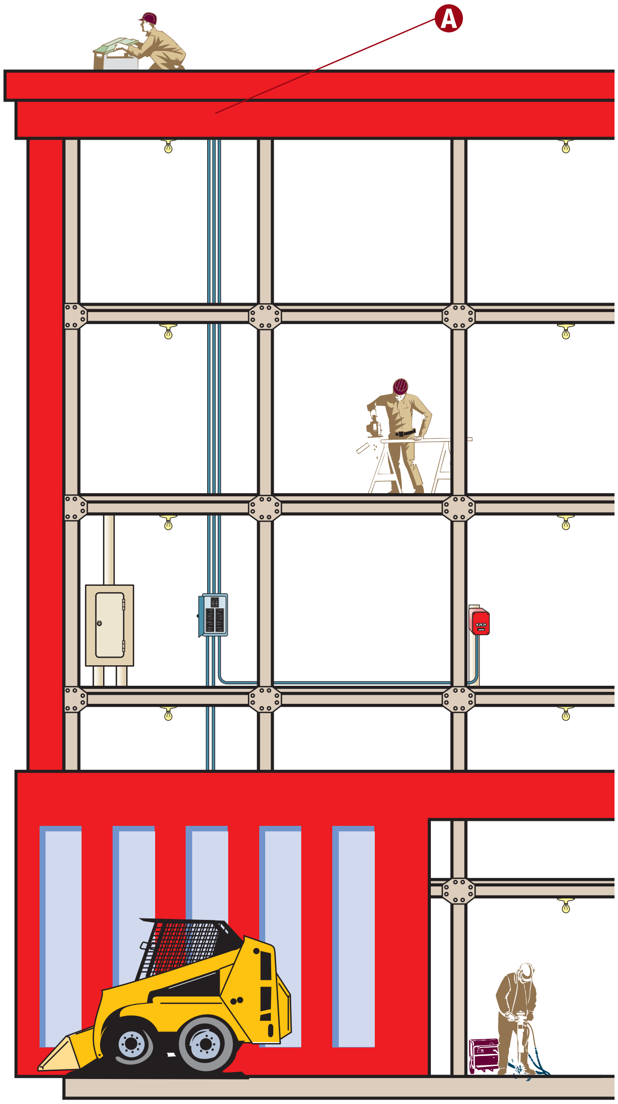
Location, Damp

Ⓐ Damp locations are those subject to moderate degrees of moisture. Damp locations are those protected from weather and not subject to saturation with water or other liquids. Examples of such locations include partially protected locations under canopies, marquees, roofed (open) porches, and similar sites as well as interior locations subject to moderate degrees of moisture such as some basements, some barns, and some cold-storage warehouses »*Article 100 and Informational Note*«.



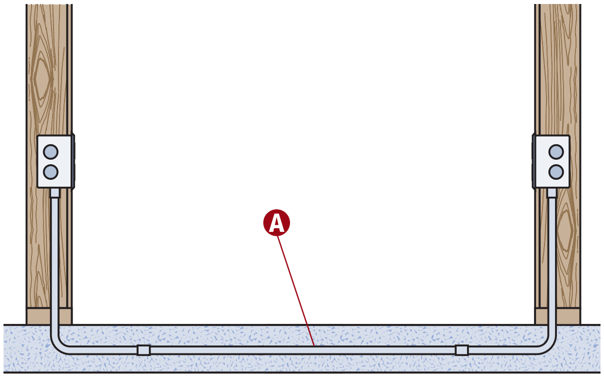
Location, Dry

Ⓐ Dry locations are those not normally subject to moisture, except on a temporary basis such as a building under construction »*Article 100*«.



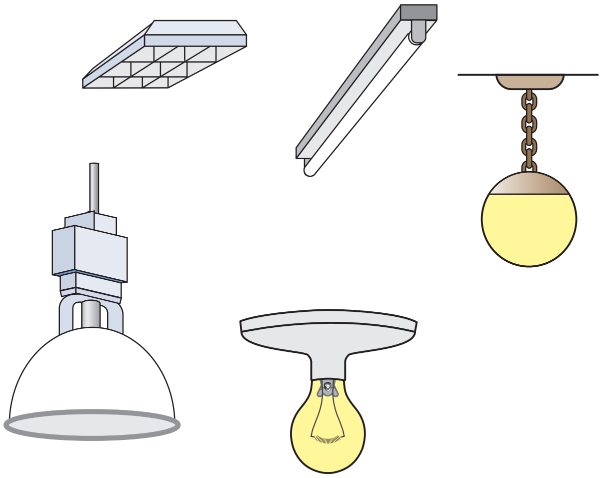
Location, Wet

Ⓐ Installations in any of the following categories are wet locations: underground, within concrete slabs, in masonry (directly contacting the earth), in areas subject to saturation (water or other liquids), and in locations unprotected from weather »*Article 100*«.



Luminaire

A luminaire is a complete lighting unit consisting of a light source such as a lamp or lamps, together with the parts designed to position the light source and to connect it to the power supply. It may also include parts to protect the light source, ballast, or distribute the light. A lampholder itself is not a luminaire »*Article 100*«.



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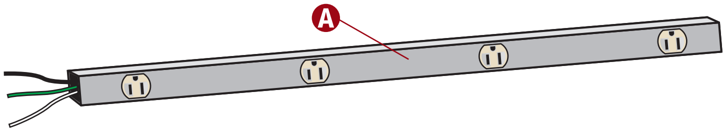
Multioutlet Assembly

A A surface, flush, or freestanding assemblage with a raceway, fittings, or other enclosure provided with one or more receptacles, for the purpose of supplying power to utilization equipment is called a multioutlet assembly »*Article 100*«.

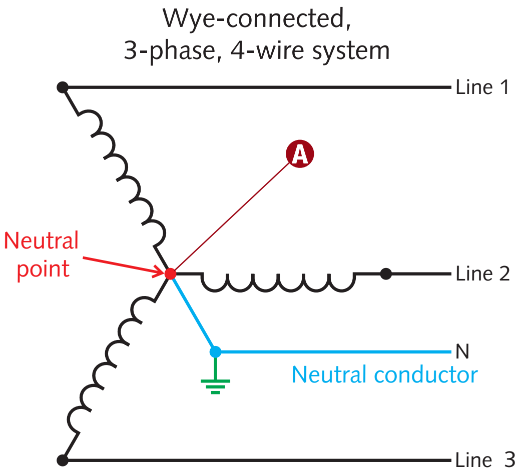


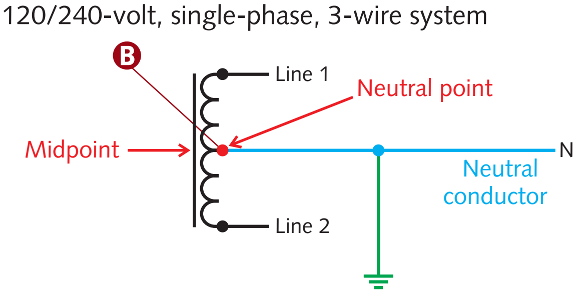
Neutral Conductor and Neutral Point

A neutral conductor is defined as the conductor connected to the neutral point of a system that is intended to carry current under normal conditions »*Article 100*«.

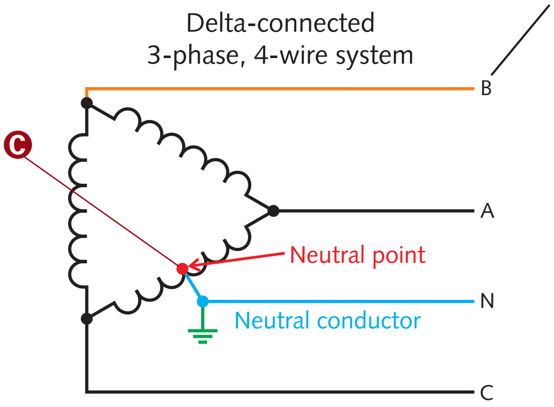
The neutral point is the common point on a wye-connection in a polyphase system or midpoint on a single-phase, 3-wire system, or midpoint of a single-phase portion of a 3-phase delta system, or a midpoint of a 3-wire, direct-current system »*Article 100*«.

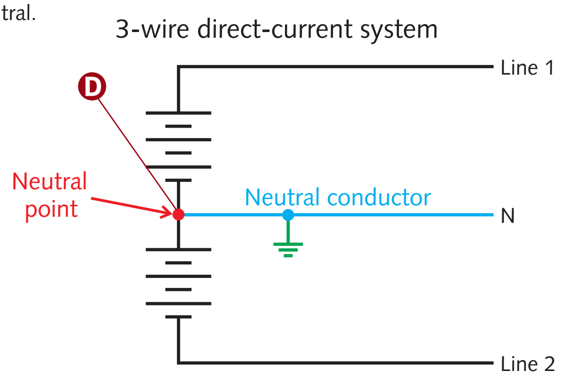
A The neutral point is the common point on a wye-connection in a polyphase system.
B The neutral point is the midpoint on a single-phase, 3-wire system.
C The neutral point is the midpoint of a single-phase portion of a 3-phase delta system.
D The neutral point is the midpoint of a 3-wire direct-current system.


Wye-connected,
3-phase, 4-wire system
Line 1
A
Neutral point
Line 2
N
Neutral conductor
Line 3


120/240-volt, single-phase, 3-wire system
B
Line 1
Neutral point
Midpoint
N
Neutral conductor
Line 2

Phase B does not utilize the neutral.


Delta-connected
3-phase, 4-wire system
B
C
A
Neutral point
N
Neutral conductor
C


3-wire direct-current system
Line 1
D
Neutral point
Neutral conductor
N
Line 2

Note

At the neutral point of the system, the vectorial sum of the nominal voltages from all other phases within the system that utilize the neutral, with respect to the neutral point, is zero potential ***»Informational Note to neutral point in Article 100«***.

Warning

Neutral conductors must be identified in accordance with the requirements in 200.6.

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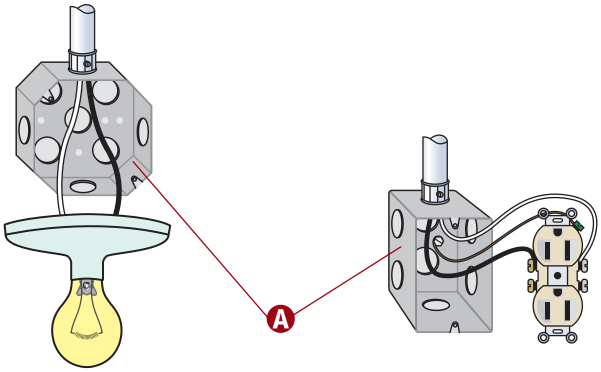
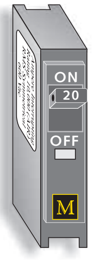
Outlet

Ⓐ A point in a wiring system from which current is taken to supply utilization equipment is known as an outlet »*Article 100*«.



Overcurrent Protective Device, Branch-Circuit

A branch-circuit overcurrent protective device is a device capable of providing protection for service, feeder, and branch circuits and equipment over the full range of overcurrents between its rated current and its interrupting rating. »*Article 100*«.



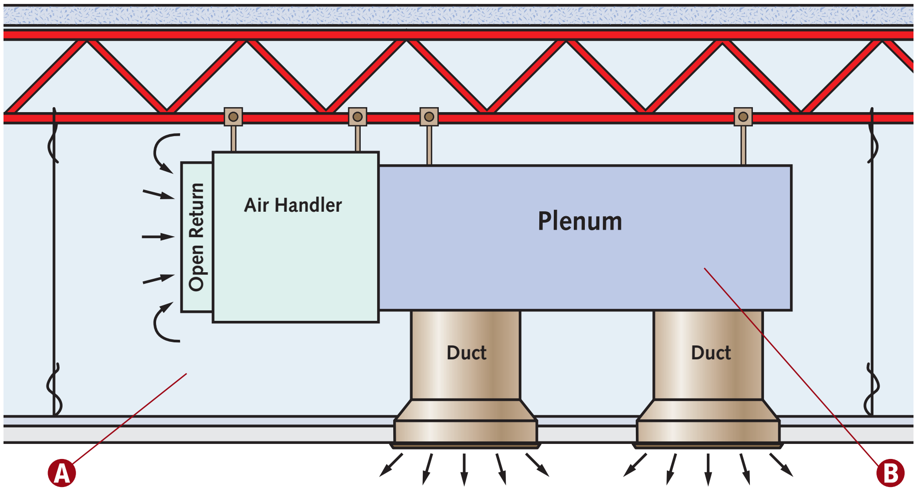
Note

A supplementary overcurrent protective device is a device intended to provide limited overcurrent protection for specific applications and utilization equipment such as luminaires and appliances. This limited protection is in addition to the protection provided in the required branch circuit by the branch-circuit overcurrent protective device **»*Article 100*«**. An in-line fuse is an example of a supplementary overcurrent device.

Plenum

Ⓐ The space above a suspended ceiling used for environmental air-handling purposes is an example of **other space used for environmental air (plenum)** as described in 300.22(C).

Ⓑ A compartment or chamber having one or more attached air ducts and forming part of the air distribution system is known as a plenum »*Article 100*«.

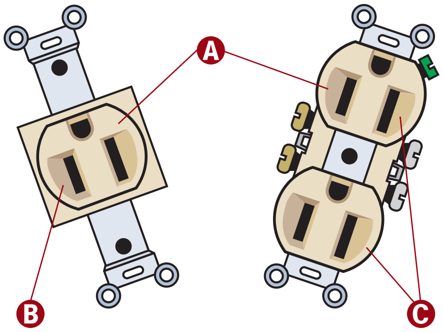


Receptacle

Ⓐ A contact device installed at an outlet for the connection of an attachment plug or for the direct connection of electrical utilization equipment designed to mate with the corresponding contact device is a receptacle »*Article 100*«.

Ⓑ A single receptacle is a single contact device with no other contact device on the same yoke or strap »*Article 100*«.

Ⓒ A multiple receptacle is two or more contact devices on the same yoke or strap »*Article 100*«.



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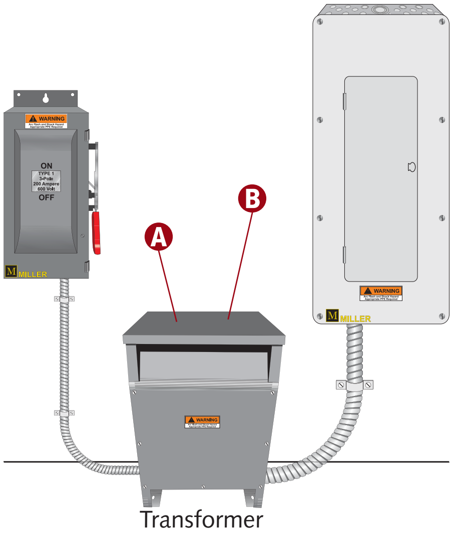
Separately Derived System

Ⓐ Article 450 contains provisions for transformers.

Ⓑ A separately derived system is an electrical power supply output, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections »*Article 100*«.

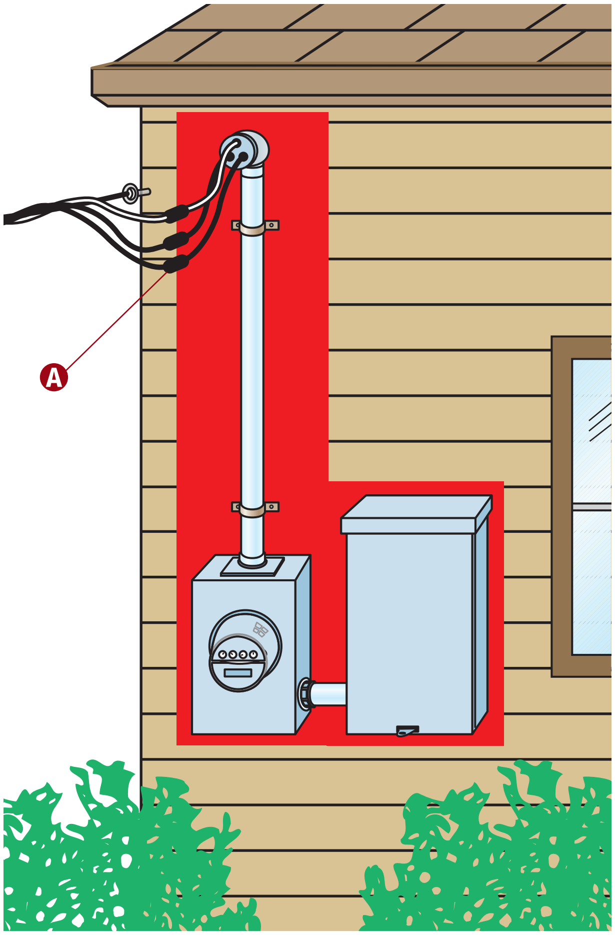
Note

An alternate ac power source, such as an on-site generator, is not a separately derived system if the grounded conductor is solidly interconnected to a service-supplied system grounded conductor ***»250.30 Informational Note No. 1«***.



Service

Ⓐ The conductors and equipment connecting the serving utility to the wiring system of the premises served is called the service »*Article 100*«.

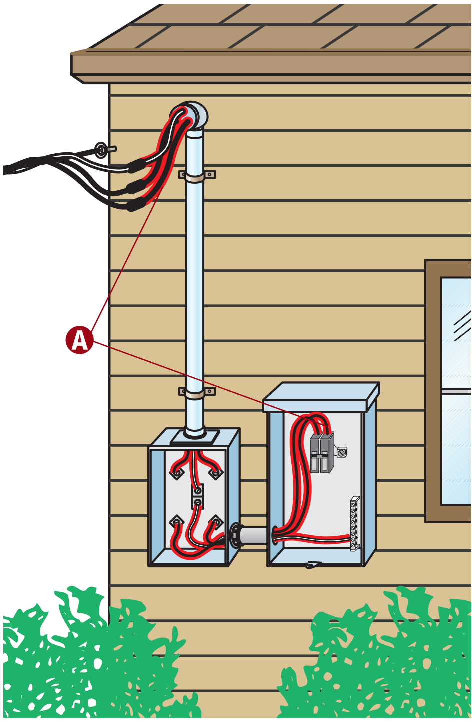


Note

Conductors and equipment are also defined as a service where receiving power underground.

Service Conductors

Ⓐ The conductors from the service point to the service disconnecting means are known as service conductors »*Article 100*«.



Note

Overhead service conductors are the overhead conductors between the service point and the first point of connection to the service-entrance conductors at the building or other structure ***»Article 100«***.

Note

Service conductors include: overhead service conductors, underground service conductors, and service-entrance conductors.

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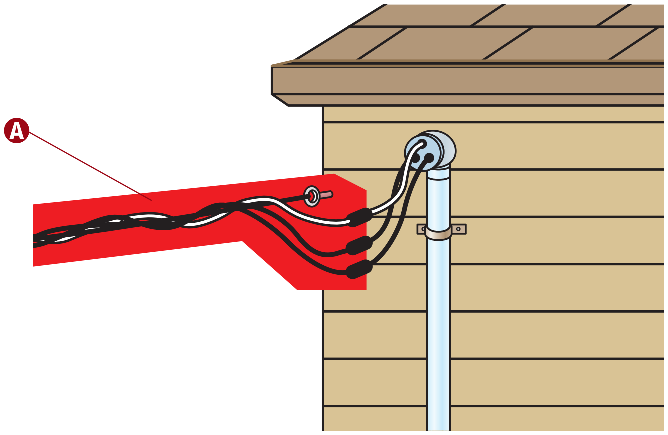
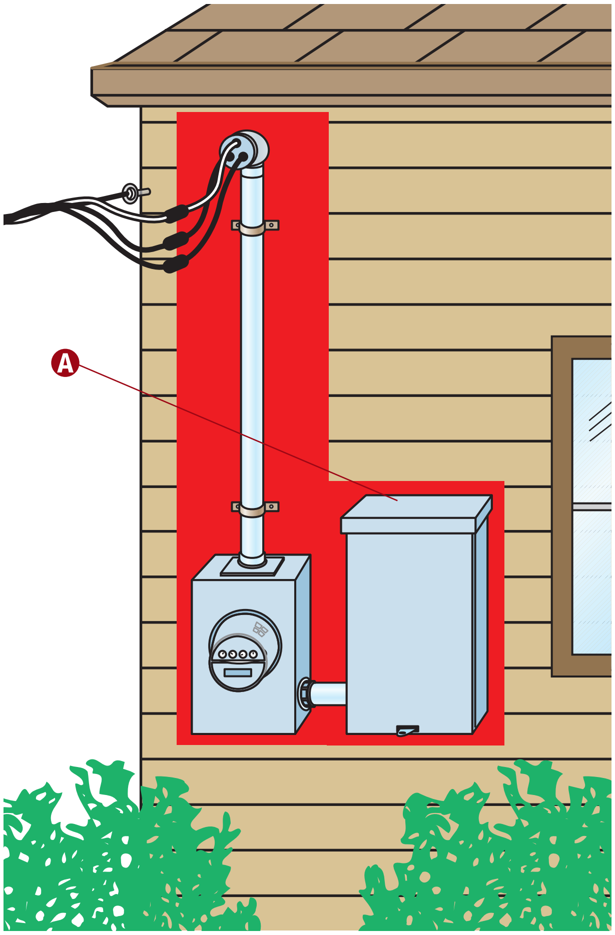
Service Drop

A The overhead conductors between the serving utility and the service point ››*Article 100*‹‹.



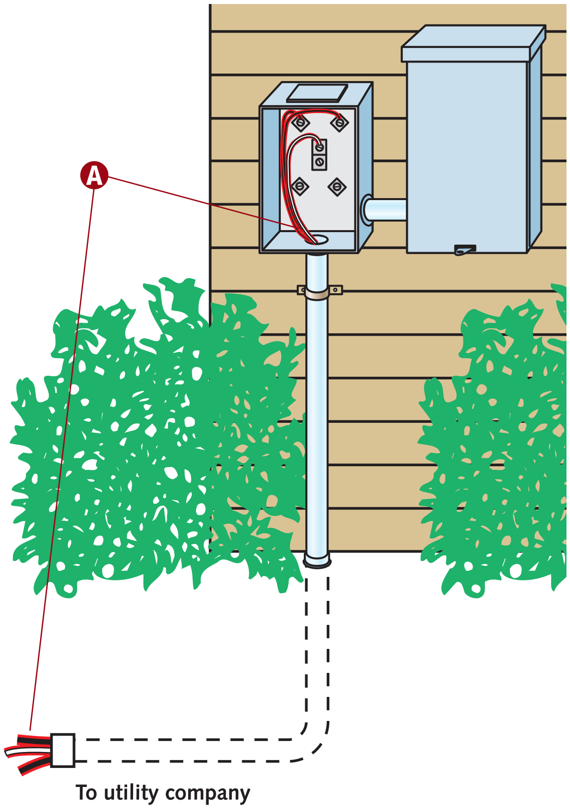
Service Equipment

A Service equipment is the necessary equipment, consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the serving utility and intended to constitute the main control and disconnect of the serving utility ››*Article 100*‹‹.



Service Lateral

A The service lateral is the underground conductors between the utility electric supply system and the service point ››*Article 100*‹‹.



Note

Underground service conductors are defined as the underground conductors between the service point and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure, inside or outside the building wall.

In accordance with the informational note under the definition of underground service conductors, where there is no terminal box, meter, or other enclosure, the point of connection is considered to be the point of entrance of the service conductors into the building ››*Article 100*‹‹.

Note

Service-entrance conductors are the service conductors between the terminals of the service equipment and the service drop, overhead service conductors, service lateral, or underground service conductors. As stated in the informational note, where service equipment is located outside the building walls, there could be no service-entrance conductors or they might be entirely outside the building ››*Article 100*‹‹.

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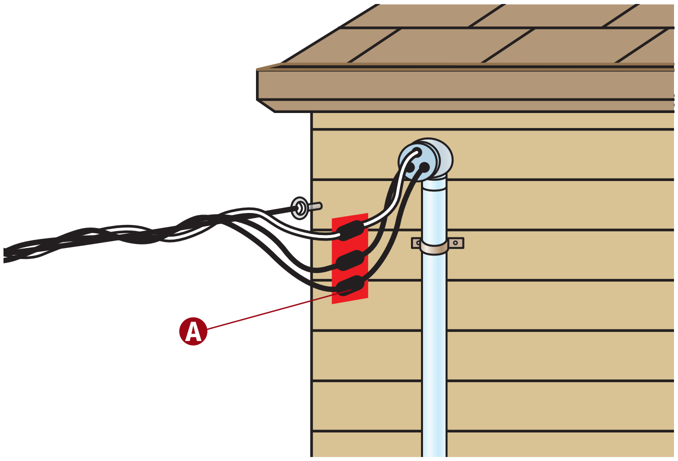
Service Point

A The service point is the point of the connection between the facilities of the serving utility and the premises wiring »*Article 100*«.

Note

The service point can be described as the point of demarcation between where the serving utility ends and the premises wiring begins. The serving utility generally specifies the location of the service point based on the conditions of service »***Article 100 Informational Note***«.

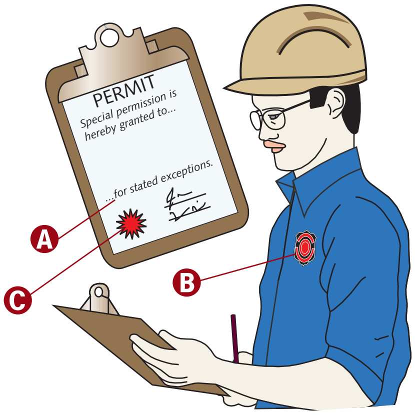


Special Permission and Authority Having Jurisdiction

A Special permission is the written consent of the authority having jurisdiction (AHJ) »*Article 100*«.

B The AHJ for enforcing the *NEC* may grant exception for the installation of conductors and equipment (not under the exclusive control of the electric utilities) used to connect the electric utility supply system to the service conductors of the premises served (provided such installations are outside a building or structure, or terminate inside at a readily accessible location nearest the point of entrance of the service conductors) »*90.2(F)*«.

C AHJ is the organization, office, or individual responsible for enforcing the requirements of a code (or standard), or for approving equipment, materials, an installation, or a procedure »*Article 100*«.


PERMIT
Special permission is hereby granted to...
...for stated exceptions.
A
B
C

Summary

- Conductors within junction boxes must be accessible without damaging the construction or finish of the building or structure.
- Certain equipment, such as the service disconnecting means, must be readily accessible.
- The term *appliance* denotes more than just kitchen equipment.
- Branch circuits are divided into five categories: appliance, general purpose, individual, motor, and multiwire.
- General-purpose branch circuits may feed lights and receptacles or any combination thereof.
- An individual branch circuit feeds only one piece of equipment.
- The terms *bonded* and *grounded* are not interchangeable.
- A multiwire branch circuit must have a means to simultaneously disconnect all ungrounded (hot) conductors.
- A load having the maximum level of current sustained for three hours or more is a continuous load.
- *Equipment* is a general term encompassing a wide variety of items.
- A grounded conductor and a grounding conductor have different functions.
- A grounded conductor is not necessarily a neutral conductor.
- One duplex receptacle is not defined as a single receptacle.
- Special permission is the written consent of the AHJ.

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Unit 2 Competency Test

NEC® Reference **Answer**

____________ ____________ 1. A(n) ____________ branch circuit supplies two or more receptacles or outlets for lighting and appliances.

____________ ____________ 2. ____________ is the largest amount of current capable of being delivered at a point on the electrical system during a short-circuit condition.

____________ ____________ 3. A(n) ____________ branch circuit consists of two or more ungrounded conductors having a potential difference between them, and a grounded conductor having equal potential difference between it and each ungrounded conductor of the circuit and that is connected to the neutral or grounded conductor of the system.

____________ ____________ 4. An intermittent operation in which load conditions are regularly recurrent is the definition of ____________.

____________ ____________ 5. The ____________ is the connection between the grounded-circuit conductor and the equipment grounding conductor at the service.

____________ ____________ 6. A(n) ____________ is used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

____________ ____________ 7. Rainproof, raintight, or watertight equipment can fulfill the requirements for ____________ where varying weather conditions other than wetness, such as snow, ice, dust, or temperature extremes, are not a factor.

____________ ____________ 8. A(n) ____________ is an intentionally constructed, low-impedance electrically conductive path designed and intended to carry current during ground-fault events from the point of a ground fault on a wiring system to the electrical supply source and that facilitates the operation of the overcurrent protective device or ground-fault detectors.

____________ ____________ 9. A(n) ____________ is a manual, nonautomatic, or automatic operated device used in conjunction with a transfer switch to provide a means of directly connecting load conductors to a power source and of disconnecting the transfer switch.

____________ ____________ 10. A surface, flush, or freestanding assemblage with a raceway, fittings, or other enclosure provided with one or more receptacles, for the purpose of supplying power to utilization equipment is called a(n) ____________.

____________ ____________ 11. A raceway encased in 4 in. (102 mm) of concrete on the ground floor (in direct contact with the earth) shall be considered a(n) ____________ location.

____________ ____________ 12. A(n) ____________ may consist of one or more sensing elements integral with the motor-compressor and an external control device.

____________ ____________ 13. An enclosure designed for either surface or flush mounting and provided with a frame, mat, or trim in which a swinging door or doors are or can be hung is called a(n) ____________.

____________ ____________ 14. A(n) ____________ is a shaftway, hatchway, well hole, or other vertical opening of space in which an elevator or dumbwaiter is designed to operate.

____________ ____________ 15. A multiwire branch circuit can supply:

I. 20/240 volts to only one piece of utilization equipment

II. 120/240 volts where all ungrounded conductors are opened simultaneously

a) I only b) II only c) both I and II d) neither I nor II

____________ ____________ 16. An overcurrent protective device with a circuit opening fusible part that is heated and severed by the passage of overcurrent through it is the definition of a(n) ____________.

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***NEC*® Reference** **Answer**

___________ ___________ 17. ___________ is a string of outdoor lights suspended between two points.

___________ ___________ 18. Name two items that must be present when defining an area as a bathroom.

___________ ___________ 19. A continuous load is where the ___________ current is expected to continue for three hours or more.

a) 80% b) average c) maximum d) 125%

___________ ___________ 20. Solidly grounded is defined as connected to ground without inserting any ___________ or impedance device.

___________ ___________ 21. A(n) ___________ is a point on the wiring system at which current is taken to supply utilization equipment.

___________ ___________ 22. A(n) ___________ is defined as the circuit conductors between the final overcurrent device protecting the circuit and the outlet(s).

___________ ___________ 23. ___________ enclosures are constructed or protected so that exposure to a beating rain will not result in the entrance of water under specified test conditions.

___________ ___________ 24. Continuous duty is an operation at a substantially constant load for ___________.

a) 1 hour or more b) 1½ hours or more

c) 3 hours or more d) an indefinitely long time

___________ ___________ 25. Ampacity is defined as the maximum current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding ___________.

___________ ___________ 26. When a disconnecting means must be located within sight from a motor, the disconnect must be visible and not more than ___________ ft from the motor.

___________ ___________ 27. A building containing three dwelling units is called a(n) ___________.

___________ ___________ 28. Ground is defined as ___________.

___________ ___________ 29. At the neutral point of the system, the ___________ of the nominal voltages from all other phases within the system that utilize the neutral, with respect to the neutral point, is zero potential.

___________ ___________ 30. Four panelboards are in an electrical room behind locked doors. Only authorized personnel have keys to this electrical room. In accordance with 240.24, overcurrent devices shall be readily accessible. Since a key must be used to gain entry into the electrical room, are the overcurrent devices in these panelboards considered readily accessible?

___________ ___________ 31. A(n) ___________ is defined as an electrical power supply output, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections.

___________ ___________ 32. A feeder is defined as all circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final ___________ overcurrent device.

___________ ___________ 33. A(n) ___________ is defined as utilization equipment, generally other than industrial, that is fastened in place, stationary, or portable; is normally built in a standardized size or type; and is installed or connected as a unit to perform one or more functions such as clothes washing, air-conditioning, food mixing, deep frying, and so forth.

___________ ___________ 34. A motor branch circuit includes the circuit conductors as well as the equipment between the motor branch-circuit short-circuit and ground-fault protective device and a(n) ___________ motor.

Unit 3

Section One: Foundational Provisions

Boxes and Enclosures

Objectives

After studying this unit, the student should be able to:

- determine the cubic-inch capacity of boxes (metal and nonmetallic) when installing 6 American Wire Gauge (AWG) and smaller conductors.
- identify which items are counted and which are not when calculating box fill.
- explain why two switches mounted side by side in a two-gang device box could each have different cubic-inch volume allowances.
- determine the minimum box size (including plaster ring, extension ring, etc.) that is needed if the number of conductors (6 AWG and smaller) is known.
- explain box requirements when using nonmetallic-sheathed cable.
- explain the minimum length of free conductor required to be left inside boxes.
- recall that boxes and conduit bodies must remain accessible after installation.
- clarify mounting and supporting provisions for boxes and conduit bodies.
- determine the type of box needed for various applications.
- explain calculation procedures for junction boxes containing 4 AWG and larger conductors.

Introduction

Choosing the right type and size of box (or enclosure) is very important to installing a system essentially free from hazard. Article 314 covers a variety of provisions concerning boxes (outlet, device, pull, and junction), conduit bodies, and fittings. Box selection must be based on requirements for a given location (such as dry, damp, wet, or hazardous). Boxes have particular requirements concerning the maximum number of conductors. Boxes containing 6 AWG and smaller conductors are required to have a minimum cubic-inch capacity, which is determined by the size and number of conductors. Boxes containing 4 AWG and larger conductors are required to have a minimum height, width, and depth that is determined by the size and number of raceway entries. Article 314 contains provisions for installing, as well as supporting, boxes and conduit bodies. Boxes must be rigidly and securely fastened in place whether mounted *on* the surface, mounted to a framing member, or mounted *in* a finished surface. Under certain conditions, the only means of support a box needs is two threaded conduits. Access to conductors and devices located within boxes and conduit bodies must be available. Article 314 covers more information than the length of this book allows, such as manholes and boxes (pull and junction) for systems over 1000 volts, nominal.

General Requirements

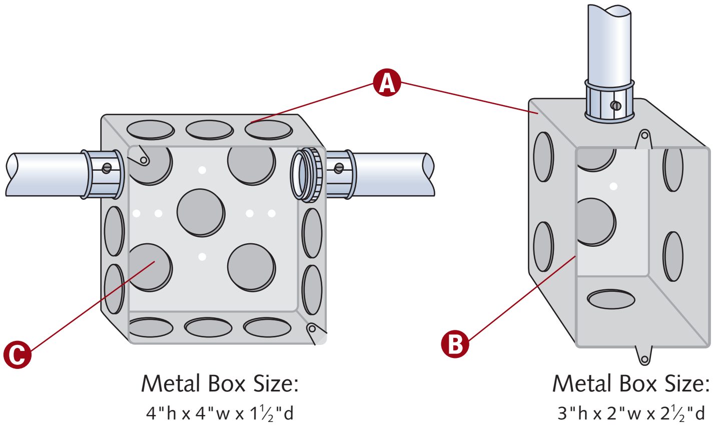
Metal Boxes

The maximum number of conductors (for sizes 18 AWG through 6 AWG) permitted in various standard size metal boxes is listed in Table 314.16(A). Minimum cubic-inch capacities are also shown.

A Volume does not have to be marked on metal boxes listed in Table 314.16(A) »*314.16(A)(2)*«.

B A 3- × 2-in. (75- × 50-mm) device box, 2½ in. (65 mm) deep, has a volume of 12.5 in.^{3} (205 cm^3) »*Table 314.16(A)*«.

C A 4-in. (100-mm) square box with a depth of 1½ in. (38 mm) has a volume of 21 in.^{3} (344 cm^3) »*Table 314.16(A)*«.



Note

Where a box is provided with one or more securely installed barriers, the volume shall be apportioned to each of the resulting spaces. Each barrier, if not marked with its volume, shall be considered to take up ½ in.^{3} (8.2 cm^3) if metal, and 1.0 in.^{3} (16.4 cm^3) if nonmetallic »***314.16(A)***«.

Note

A means shall be provided in each metal box for the connection of an equipment grounding conductor. The means shall be permitted to be a tapped hole or equivalent »***314.100(D)***«.

Volume Markings on Metal Boxes

It is permissible to use the volume marked on a metal box even if it is more than is shown in Table 314.16(A) for the same size box »*314.16(A)(2)*«.

A The minimum volume for this size box in Table 314.16(A) is 21.5 in.^{3}.

B The volume marked on this box is 22.5 in.^{3}.

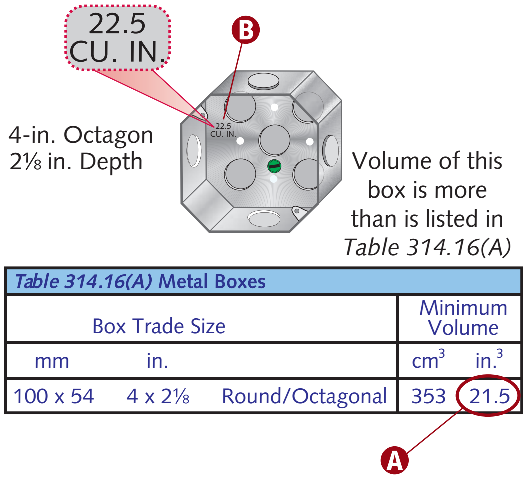
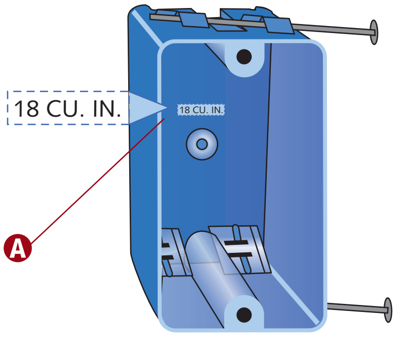

22.5 CU. IN.
B
22.5 CU. IN.
4-in. Octagon
2⅛ in. Depth
Volume of this box is more than is listed in *Table 314.16(A)*
A

Table 314.16(A) Metal Boxes				
Box Trade Size			Minimum Volume	
mm	in.		cm^3	in.^{3}
100 x 54	4 x 2⅛	Round/Octagonal	353	21.5

Nonmetallic Boxes

A Volume shall be marked on all nonmetallic boxes and boxes with a volume of 100 in.^{3} (1650 cm^3) or less, except for boxes listed in Table 314.16(A) »*314.16(A)(2)*«.



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Additional Capacity

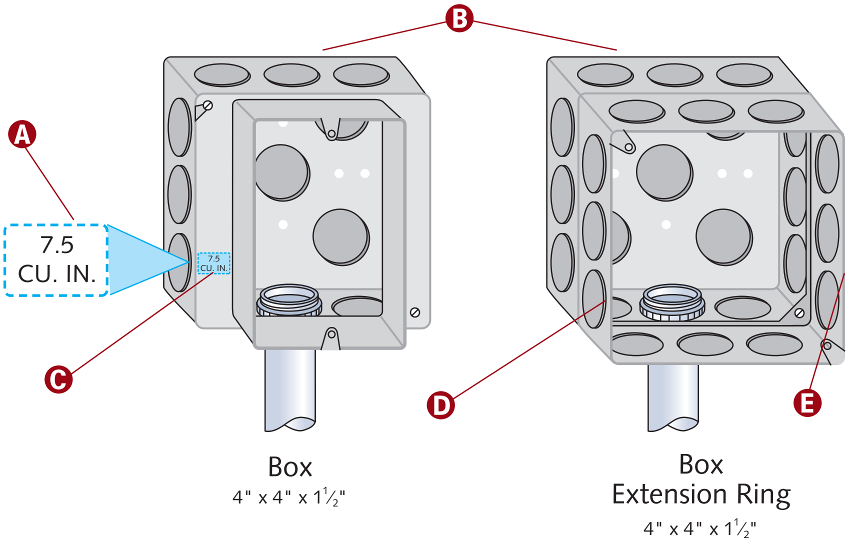
A Additional capacity can only be calculated when the plaster ring, extension ring, etc. is clearly marked with a volume or when it corresponds in size to a box listed in Table 314.16(A).

B Volume can be increased by using plaster (mud) rings, domed covers, extension rings, or similar items »*314.16(A)*«.

C The combined volume of this box and plaster (mud) ring is 28.5 in.^{3} (467 cm^3) »*Table 314.16(A)*«.

D The combined volume of the box and extension ring is 42 in.^{3} (688 cm^3) »*Table 314.16(A)*«.

E A 4-in. (100-mm) square extension ring, having a depth of 1½ in. (38 mm), has a capacity of 21 in.^{3} (344 cm^3) because it has the same dimensions as a box listed in Table 314.16(A).


B
A
7.5 CU. IN.
C
D
E
Box
4" x 4" x 1½"
Box Extension Ring
4" x 4" x 1½"

Additional Markings

A All nonmetallic boxes must be durably and legibly marked by the manufacturer with the volume of the box.

B Some nonmetallic boxes are marked with the maximum number of certain sizes of conductors. This marking is not required.

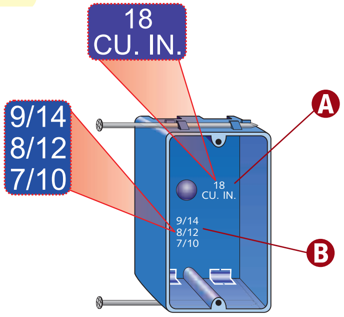
C The maximum number of conductors applies only if the box does not contain any fittings or devices.

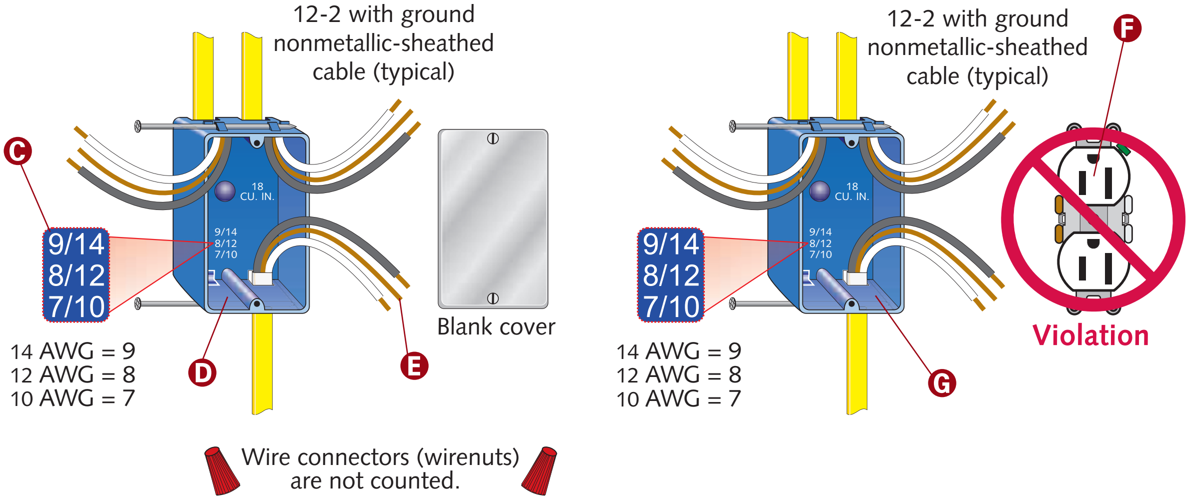
D The box fill calculation for this box is seven 12 AWG conductors. Because eight 12 AWG conductors are permitted, this installation is *Code* compliant.

E The three equipment grounding conductors in this box count as one conductor.

F Installing a device in this box is a violation of *314.16*.

G Because the calculated number of 12 AWG conductors in this box is seven and a device counts as two 12 AWG conductors, the total number of 12 AWG conductors would be nine. In accordance with the marking on this box, only eight 12 AWG conductors are permitted.


18 CU. IN.
9/14
8/12
7/10
A
B


12-2 with ground nonmetallic-sheathed cable (typical)
C
9/14
8/12
7/10
14 AWG = 9
12 AWG = 8
10 AWG = 7
D
E
Blank cover
12-2 with ground nonmetallic-sheathed cable (typical)
F
Violation
G
Wire connectors (wirenuts) are not counted.

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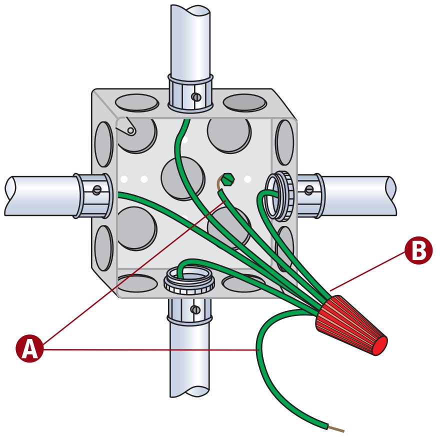
Box Fill Calculations

Equipment Grounding Conductor Fill

Where up to four equipment grounding conductors enter a box, a single volume allowance in accordance with Table 314.16(B)(1) shall be made based on the largest equipment grounding conductor entering the box. A ¼ volume allowance shall be made for each additional equipment grounding conductor that enters the box, based on the largest equipment grounding conductor entering the box »*314.16(B)(5)*«.

A Conductors that do not leave the box, such as equipment bonding jumpers and pigtails, are not counted »*314.16(B)(1)*«.

B Equipment grounding conductor(s) entering a box count as one conductor unless there are more than four equipment grounding conductors »*314.16(B)(5)*«. Only the largest equipment grounding conductor shall be counted if multiple grounding conductors (of different sizes) enter the box.



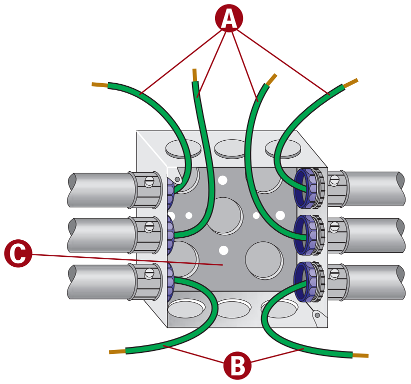
Equipment Grounding Conductor Fill—More Than Four Conductors

Where up to four equipment grounding conductors enter a box, a single volume allowance in accordance with Table 314.16(B)(1) shall be made based on the largest equipment grounding conductor entering the box. A ¼ volume allowance shall be made for each additional equipment grounding conductor that enters the box, based on the largest equipment grounding conductor entering the box »*314.16(B)(5)*«.

A These first four equipment grounding conductors count as one 14 AWG conductor. As shown in Table 314.16(B)(1), the volume allowance required for a 14 AWG conductor is 2 in.^{3}. The volume allowance required for these four 14 AWG equipment grounding conductors is 2 in.^{3}.

B Because there are two additional equipment grounding conductors (more than four), each of these equipment grounding conductors require a ¼ volume allowance. As shown in Table 314.16(B)(1), the volume allowance required for a 14 AWG conductor is 2 in.^{3}. The volume allowance required for each of these additional 14 AWG equipment grounding conductors is 0.5 in.^{3} (2 × 0.25 = 0.5). The volume allowance required for two additional 14 AWG equipment grounding conductors is 1 in.^{3} (2 × 0.5 = 1).

C The volume allowance required for all six of these 14 AWG equipment grounding conductors is 3 in.^{3} (2 + 1 = 3).



Six 14 AWG equipment grounding conductors

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Determining the Number of Conductors

A Raceway fittings (connectors, hubs, etc.) are not counted.

B Each conductor originating outside the box that is terminated or spliced inside the box counts as one conductor »*314.16(B)(1)*«. These red conductors are counted as two conductors.

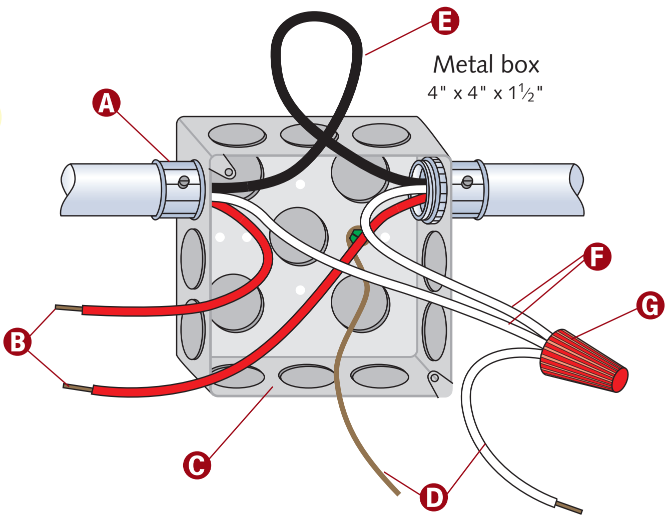
C This box, as pictured, contains five conductors. If all of the conductors are 12 AWG, the box could hold a maximum of nine conductors »*Table 314.16(A)*«.

D A conductor that does not leave the box, such as equipment bonding jumpers and pigtails, is not counted »*314.16(B)(1)*«.

E A conductor that passes through the box without splice or termination (unbroken) counts as one conductor. Each loop or coil of unbroken conductor not less than twice the minimum length required for free conductors in 300.14 must be counted twice »*314.16(B)(1)*«. This black unbroken conductor is counted as one conductor.

F Each conductor originating outside the box that is terminated or spliced inside the box counts as one conductor »*314.16(B)(1)*«. These white conductors count as two conductors.

G Wire connectors are not counted.



Note

Each space within a box installed with a barrier shall be calculated separately »*314.16(A)*«.

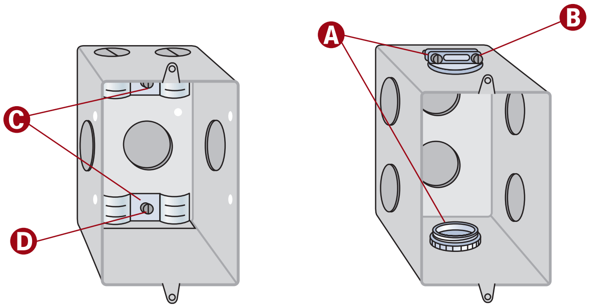
Cable Clamps and Connectors

A External cable connectors are not counted.

B Cable connector(s) with the clamping mechanism outside the box are not counted »*314.16(B)(2)*«.

C Two internal cable clamps count as one conductor.

D Internal cable clamp(s), whether factory or field supplied, shall be counted as one conductor »*314.16(B)(2)*«. Where more than one size conductor is present in the box, the clamp shall be counted as the largest conductor.

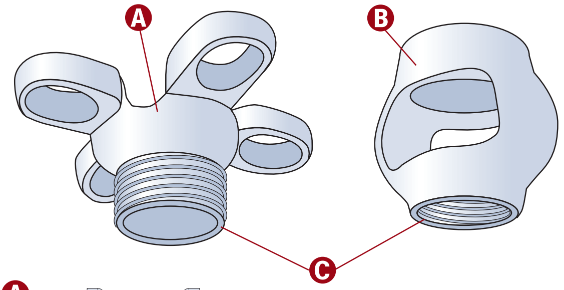


Luminaire Studs and Hickeys

A Luminaire stud(s) shall be counted as one conductor »*314.16(B)(3)*«.

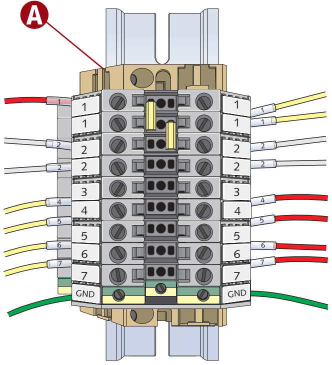
B One or more hickeys shall be counted as one conductor »*314.16(B)(3)*«.

C If conductors of different sizes are present in the box, each one shall be counted as the largest conductor »*314.16(B)(3)*«.



Terminal Block Fill

A Where a terminal block is present in a box, a single volume allowance in accordance with Table 314.16(B)(1) shall be made for each terminal block assembly based on the largest conductor(s) terminated to the assembly »*314.16(B)(6)*«.

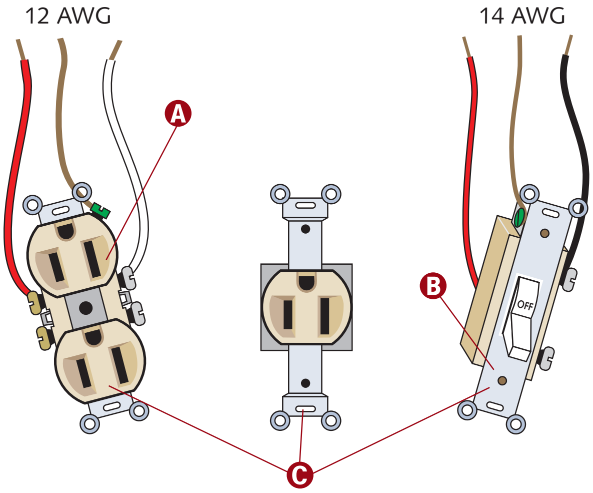


Devices or Equipment

Ⓐ This duplex receptacle counts as two 12 AWG conductors.

Ⓑ This single-pole switch counts as two 14 AWG conductors.

Ⓒ Each mounting yoke or strap counts as two conductors. A mounting yoke or strap can contain one or more devices, such as a single receptacle, a duplex receptacle, a single switch, a double switch, a triple switch, or any combination. The size of the two conductors (when calculating box fill) shall be equal in size to the largest conductor connected to the device »*314.16(B)(4)*«.



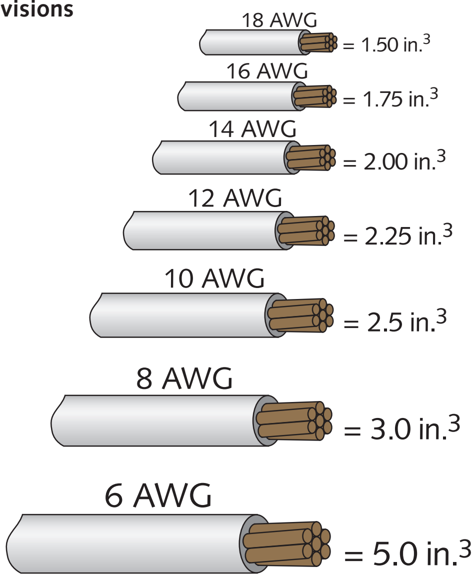
Volume per Conductor

Table 314.16(B)(1) lists the cubic-inch volume for conductors, sizes 18 AWG through 6 AWG.

Boxes, enclosures, and conduit bodies containing conductors, size 4 AWG or larger, must also comply with 314.28 provisions »*314.16*«.

Note

Conductor insulation is not a factor when determining box fill calculations.



Note

A device or utilization equipment wider than a single 2-in. (50-mm) device box as described in Table 314.16(A) shall have double-volume allowances provided for each gang required for mounting »*314.16(B)(4)*«.

Box Fill Calculation

Wire connectors, pigtails, locknuts, bushings, raceway connectors, grounding screws, and equipment bonding jumpers are not factors when calculating box fill.

Ⓐ These three conductors, although spliced, count as *three* conductors.

Ⓑ Two conductors that terminate in the box count as *two* conductors.

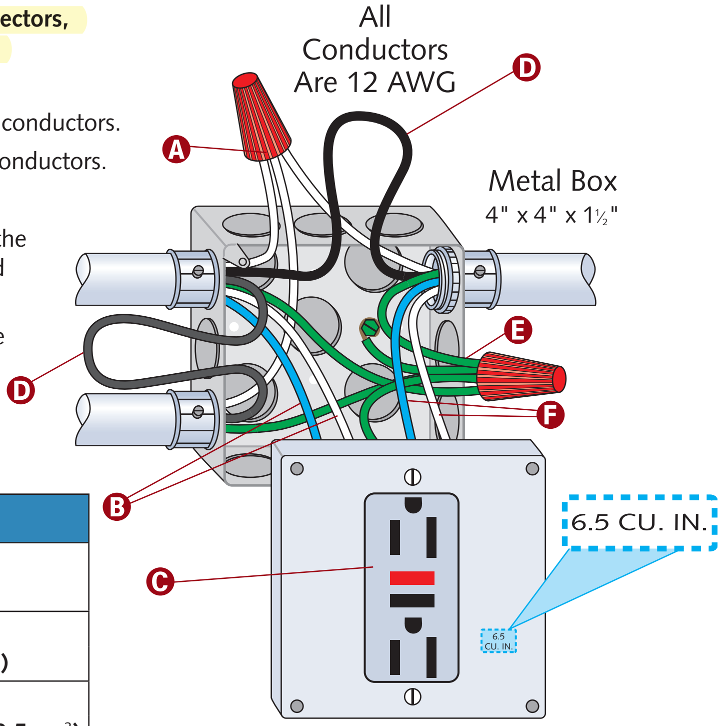
Ⓒ One receptacle counts as *two* 12 AWG conductors.

Ⓓ An unbroken conductor counts as *one* conductor unless the conductor is not less than twice the minimum length required for free conductors in 300.14.

Ⓔ These three equipment grounding conductors that enter the box from the three raceways count as *one* conductor.

Ⓕ These two conductors terminating in the box are counted as *two* conductors.

Total 12 AWG conductors: Twelve	
Volume per 12 AWG	2.25 in.^{3} (each) (36.9 cm^3 [each])
Minimum volume for conductors	12 × 2.25 in.^{3} = 27 in.^{3} (12 × 36.9 cm^3 = 442.8 cm^3)
Volume for box (including raised cover)	21 in.^{3} + 6.5 in.^{3} = 27.5 in.^{3} (344 cm^3 + 106.5 cm^3 = 450.5 cm^3)
This installation complies with 314.16 provisions.	



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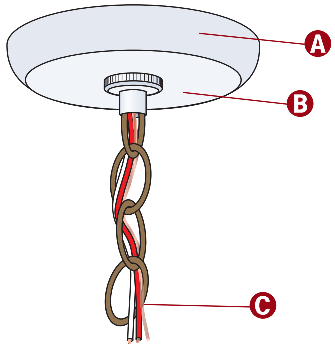
Domed Covers and Canopies

Ⓐ Four or fewer luminaire wires (smaller than 14 AWG) and an equipment grounding conductor can be omitted from box fill calculations where they enter a box from a domed luminaire (or similar canopy) and terminate within that box *»314.16(B)(1) Exception«*.

Ⓑ The size of the domed cover or canopy is not a factor.

Ⓒ Two luminaire wires and one equipment ground are not counted.



Splices Inside Conduit Bodies

Ⓐ Splices, taps, or devices are permitted inside conduit bodies, if the manufacturer durably and legibly marked the cubic-inch capacity on the conduit body *»314.16(C)(2)«*.

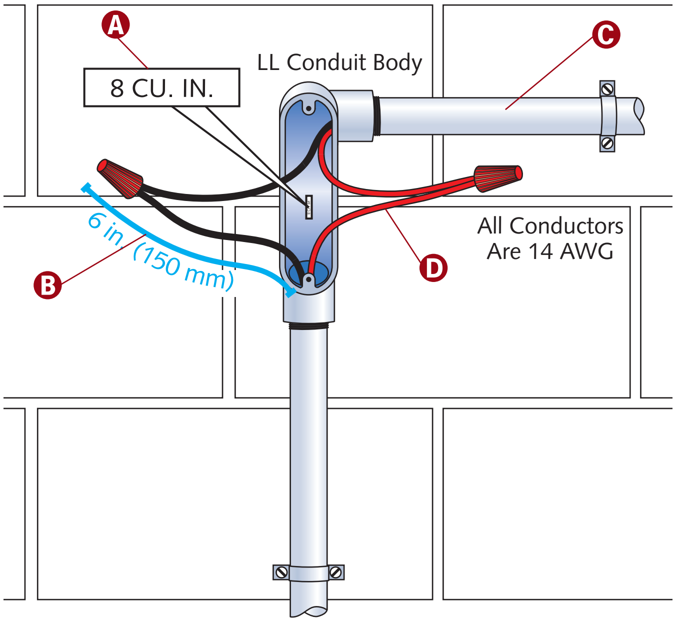
Ⓑ At least 6 in. (150 mm) of free conductor (measured from the point in the conduit body where it emerges from its raceway or cable sheath) shall be left at each outlet, junction, and switch point *»300.14«*.

Ⓒ A conduit body can be supported by rigid metal conduit, intermediate metal conduit, rigid nonmetallic conduit, or electrical metallic tubing *»314.23(E) Exception«*.

Ⓓ The maximum number of conductors shall be calculated in accordance with 314.16(B). Four 14 AWG conductors with a volume of 2.0 $in.^3$ (32.8 cm^3) each require a total volume of 8 $in.^3$ (131.2 cm^3).

Note

The maximum number of conductors permitted shall be the maximum number permitted by Table 1 of Chapter 9 for the conduit to which it is attached ***»314.16(C)(1)«***.



General Installation

Securing Cables to Metal Boxes

Conductors must be protected from abrasion where entering boxes, conduit bodies, or fittings *»314.17«*.

Ⓐ A connection used for no other purpose shall be made between the equipment grounding conductor(s) and a metal box in accordance with 250.8 *»250.148(C)«*. Grounding conductors must not be connected to enclosures with screws that engage less than two threads in the enclosure (or nut) such as sheet metal, drywall, or wood screws (see 250.8).

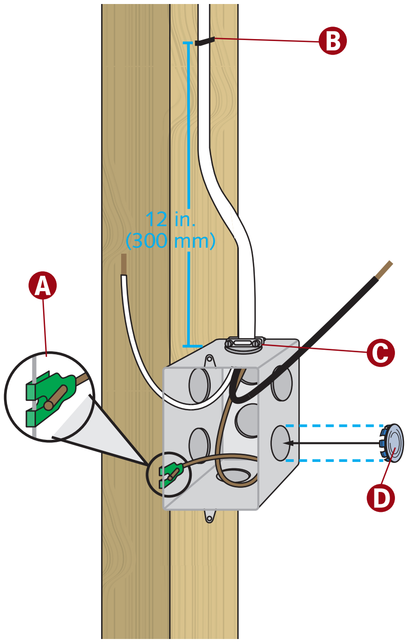
Ⓑ Nonmetallic-sheathed cable shall be secured within 12 in. (300 mm) of every cabinet, box, or fitting. The cable can be secured by using staples; cable ties listed, labeled, and identified for securement and support; or straps, hangers, or similar fittings designed and installed so that the cable remains undamaged *»334.30«*.

Ⓒ Cables must be securely fastened to any metal box or conduit body that they enter *»314.17(B)(2)«*. The clamping mechanism can be internal or external to the box or conduit body.

Ⓓ Unused cable or raceway openings in boxes and conduit bodies must be closed so that the protection provided is at least equal to that provided by the wall of the box or conduit body *»110.12(A)«*.

Caution

Where nonmetallic-sheathed cable or multiconductor Type UF cable is used, the sheath shall extend not less than ¼ in. (6 mm) inside the box and ¼ in. beyond the end of any cable clamp *»314.17(B)(2)«*.



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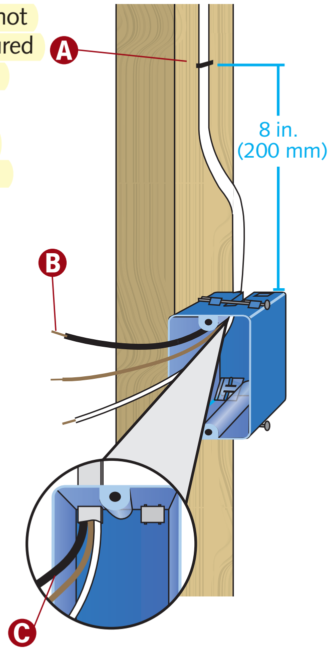
Single-Gang Nonmetallic Boxes

A Nonmetallic-sheathed cable not fastened to the box must be secured within 8 in. (200 mm) of the box »*314.17(B)(2) Exception*«.

B At least 6 in. (150 mm) of free conductor (measured from the point in the box where it emerges from its raceway or cable sheath) shall be left at each outlet, junction, and switch point »*300.14*«.

C The cable sheath shall extend into the box at least ¼ in. (6 mm) through the cable knockout or opening »*314.17(B)(2) Exception*«.



Caution

All permitted wiring methods must be secured to the box, unless the exception in 314.17(B)(2) has been met.

Securing Cables to Nonmetallic Boxes

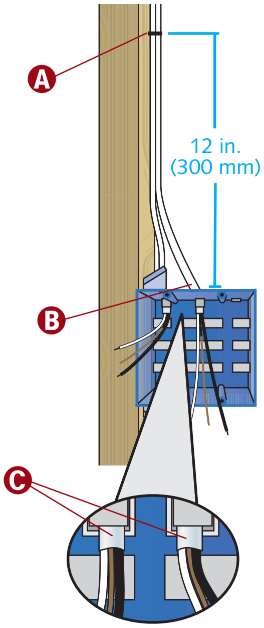
A Nonmetallic-sheathed cable shall be secured within 12 in. (300 mm) of every cable entry into enclosures such as outlet boxes, junction boxes, cabinets, or fittings »*334.30*«.

B Cables entering a nonmetallic box must be secured to the box, unless it is a single-gang nonmetallic box »*314.17(B)(2)*«.

C The cable sheath shall extend into the box at least ¼ in. (6 mm) through the cable knockout or opening »*314.17(B)(2)*«.

Note

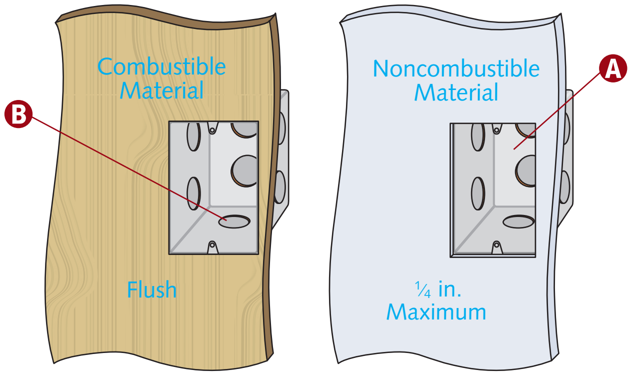
The exception pertaining to nonmetallic-sheathed cable entering a box which has no means of securing the cable to the box applies only to *single-gang* nonmetallic boxes ***»314.17(B)(2) Exception«***.



Boxes in Combustible and Noncombustible Materials

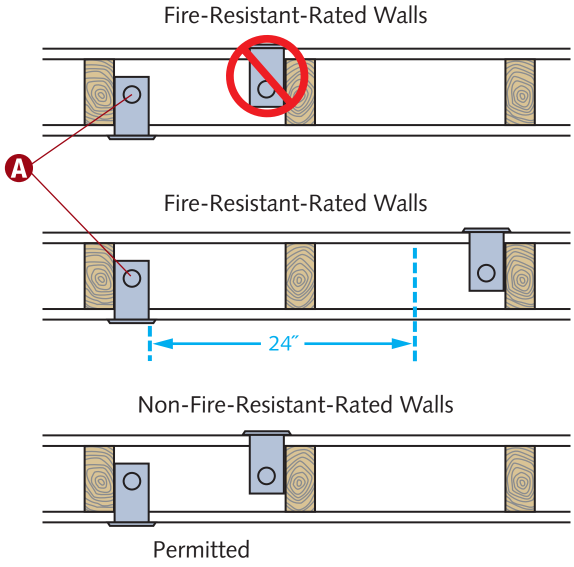
A Flush-mounted installations within or behind a surface of noncombustible material such as concrete, tile, gypsum, and plaster, including boxes employing a flush-type cover or faceplate, shall be made so that the front edge of the box, plaster ring, extension ring, or listed extender will not be set back more than ¼ in. (6 mm) of the finished surface »*314.20*«.

B For installations within a surface of wood or other combustible surface material, boxes, plaster rings, extension rings, or listed extenders shall extend to the finished surface or project therefrom »*314.20*«.



Back-to-Back Boxes in Fire-Resistant-Rated Wall

A Qualified testing laboratories publish electrical construction material directories listing installation restrictions that apply to maintaining fire-resistive ratings of assemblies involving penetrations, or openings. (An example is the minimum 24-in. [600-mm] horizontal separation usually required between boxes on opposite sides of the wall.) These fire-resistance directories, product listings, and building codes offer assistance in 300.21 compliance »*300.21 (Informational Note)*«.


Fire-Resistant-Rated Walls
A
Fire-Resistant-Rated Walls
24″
Non-Fire-Resistant-Rated Walls
Permitted

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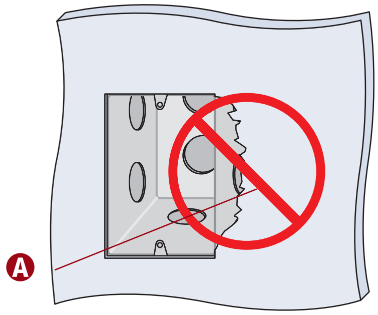
Gaps or Open Spaces

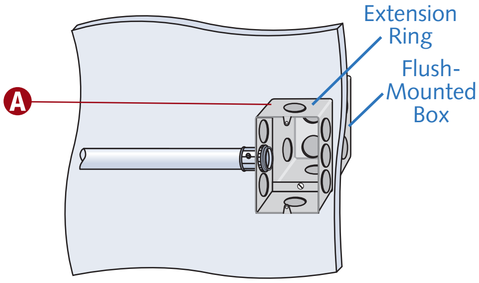
A Damaged or incomplete plaster, drywall, or plasterboard surfaces around boxes employing a flush-type cover or faceplate must be repaired so that no gap or open space greater than ⅛ in. (3 mm) surrounds the box or fitting »*314.21*«.



Surface Extensions

Equipment grounding, where required, must be in accordance with Part VI of Article 250.

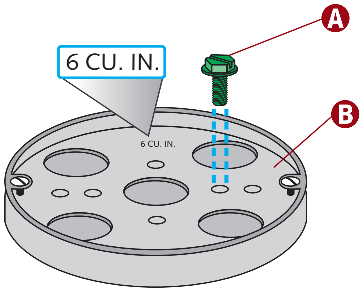
A Surface extensions must have an extension ring mounted and mechanically secured to the box »*314.22*«.



Minimum Internal Depth

A Except as permitted in 250.112(I), all metal boxes shall be grounded and bonded in accordance with Parts I, IV, V, VI, VII, and X of Article 250, as applicable »*314.4*«.

B Outlet boxes that do not enclose devices or utilization equipment must have an internal depth of at least ½ in. (12.7 mm) »*314.24(A)*«.

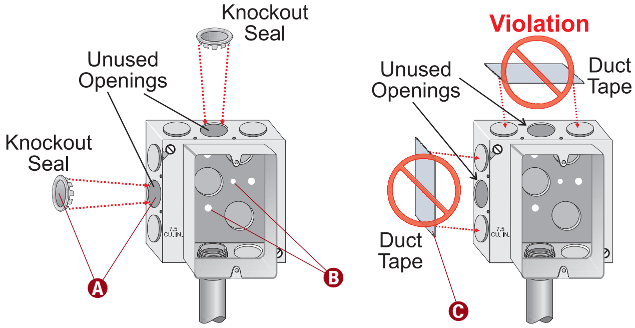

6 CU. IN.
6 CU. IN.
A
B

Unused Openings

A Unused openings shall be closed to afford protection substantially equivalent to the wall of the equipment »*110.12(A)*«.

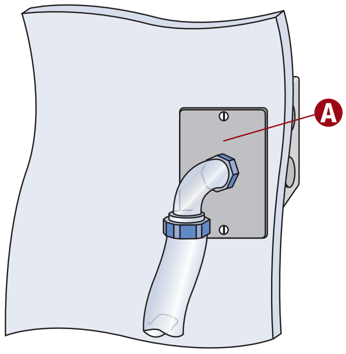
B It is not required to close openings intended for the operation of equipment, openings intended for mounting purposes, or openings permitted as part of the design for listed equipment »*110.12(A)*«.

C Duct tape does not provide protection equivalent to the wall of the box.



Surface Extensions Made from Covers

A The cover of a flush-mounted box can provide a surface extension where the cover is designed so that it is unlikely to fall off or be removed if its securing means becomes loose. The wiring method shall be flexible for an approved length that permits removal of the cover and provides access to the box interior and shall be arranged so that any grounding continuity is independent of the connection between the box and the cover »*314.22 Exception*«.



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Metal Faceplates Covering Nonmetallic Boxes

Ⓐ Snap switches (including dimmer and control switches) must be connected to an equipment grounding conductor and must also provide a means to connect metal faceplates to the equipment grounding conductor, even if a metal faceplate is not installed »*404.9(B)*«.

Ⓑ Both metal and nonmetallic covers and plates shall be permitted. Metal covers or plates, when used, must comply with 250.110 grounding requirements »*314.25(A)*«.

Ⓒ Should the snap switch enclosure, or the wiring method used, not have an equipment ground, a snap switch without a grounding connection can be used for replacement purposes only. A snap switch wired under the provisions of this exception and located within 8 ft (2.5 m) vertically, or 5 ft (1.5 m) horizontally, of ground or exposed grounded metal objects shall be provided with a faceplate of nonconducting noncombustible material with nonmetallic attachment screws, unless the switch mounting strap or yoke is nonmetallic or the circuit is protected by a ground-fault circuit interrupter »*404.9(B) Exception No. 1*«.

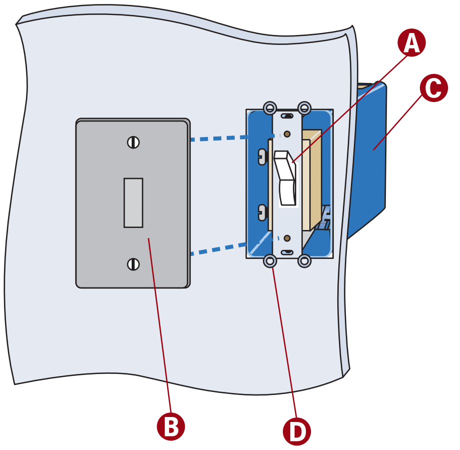
Ⓓ There are two acceptable methods for grounding snap switches effectively: (1) The switch is mounted with metal screws to a metal box or metal cover that is connected to an equipment grounding conductor or to a nonmetallic box equipped with integral means for connecting to an equipment grounding conductor. (2) An equipment grounding conductor, or equipment bonding jumper, is connected to the equipment grounding termination on the snap switch »*404.9(B)*«.

Caution

Isolated ground receptacles, in nonmetallic boxes, must be covered with either a nonmetallic faceplate or with an effectively grounded metal faceplate »*406.3(E)(2)*«.

Note

Metal receptacle faceplates (cover plates) shall be grounded ***»404.9(B) and 406.6(B)«***.



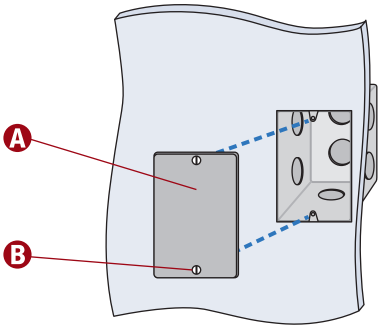
Note

Listed kits or listed assemblies shall not be required to be connected to an equipment grounding conductor if all of the following conditions are met:
(1) The device is provided with a nonmetallic faceplate and is designed such that no metallic faceplate replaces the one provided,
(2) The device does not have mounting means to accept other configurations of faceplates,
(3) The device is equipped with a nonmetallic yoke, and
(4) All parts of the device that are accessible after installation of the faceplate are manufactured of nonmetallic materials ***»404.9(B) Exception No. 2«***.

Covers and Canopies

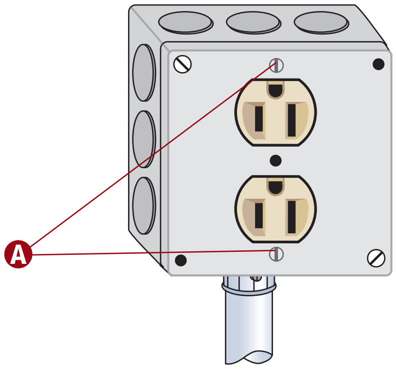
Ⓐ To complete the installation, each box must have a cover, faceplate, lampholder, or luminaire canopy, except where the installation complies with 410.24(B) »*314.25*«.

Ⓑ Screws used for the purpose of attaching covers, or other equipment, to the box shall be either machine screws matching the thread gauge or size that is integral to the box or shall be in accordance with the manufacturer's instructions »*314.25*«.



Receptacles Mounted on Covers

Ⓐ Where receptacles are mounted and supported by a cover, they must be secured by more than one screw, unless the box cover or device assembly is listed and identified as single-screw mounting »*406.5(C)*«.

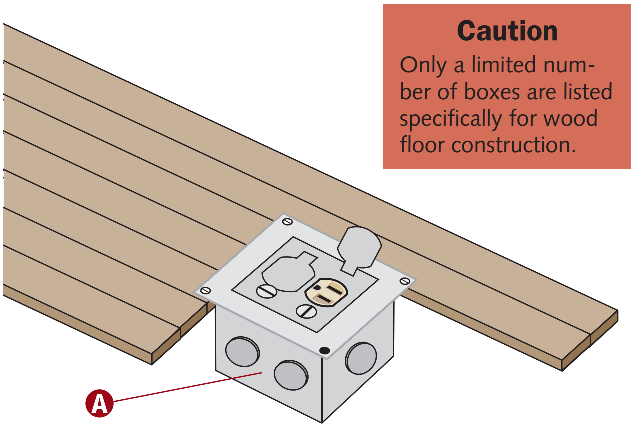


Floor Boxes

Ⓐ Boxes containing receptacles, located in the floor, must be listed for the specific application »*314.27(B)*«.

Note

Boxes located in elevated floors (such as show windows) do not have to be listed specifically as floor boxes if the authority having jurisdiction (AHJ) judges them free from likely exposure to physical damage, moisture, and dirt. Receptacles and covers shall be listed as an assembly for this type of location »***314.27(B) Exception***«.



Caution

Only a limited number of boxes are listed specifically for wood floor construction.

Access to Outlet Boxes

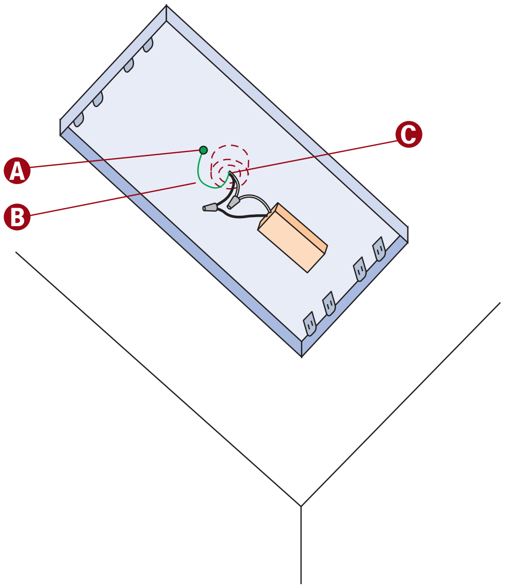
Ⓐ Unless meeting one of the two exceptions, luminaires and equipment shall be mechanically connected to an equipment grounding conductor as specified in 410.42 »*410.44*«.

Ⓑ A means for connecting an equipment grounding conductor must be provided for luminaires with exposed metal parts »*410.42*«.

Ⓒ Electric-discharge luminaires, such as fluorescent luminaires, that are surface mounted over concealed boxes (outlet, pull, or junction) and are designed not to be supported solely by the outlet box shall have suitable openings in back of the luminaire providing access to the wiring in the box »*410.24(B)*«. This provision also applies to LED luminaires.

Note

Supplementary overcurrent protective devices, when used within luminaires, do not have to be readily accessible »***240.10***«.



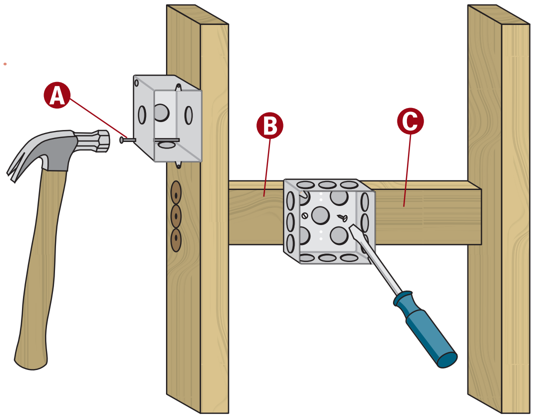
Box and Luminaire Support

Box and Enclosure Supports

Ⓐ Nails, where used, can attach brackets on the outside of the enclosure or by using mounting holes in the back or in a single side of the enclosure, or they shall pass through the interior within ¼ in. (6 mm) of the back or ends of the enclosure »*314.23(B)(1)*«.

Ⓑ An enclosure supported from a structural member or from grade shall be rigidly supported either directly or by use of a brace (metal, polymeric, or wood) »*314.23(B)*«.

Ⓒ Wood braces must have a cross section of at least 1 in. by 2 in. (25 mm by 50 mm) »*314.23(B)(2)*«.



Note

An enclosure mounted on a building or other surface shall be rigidly and securely fastened in place. If the mounting surface does not provide rigid and secure support, additional support must be provided in accordance with 314.23 provisions »***314.23(A)***«.

Caution

Screws passing through the box (with exposed threads in the box) are not permitted, unless they are protected using approved means. Exposed threads could be abrasive to conductor insulation. Mounting holes made in the field shall be approved »***314.23(B)(1)***«.

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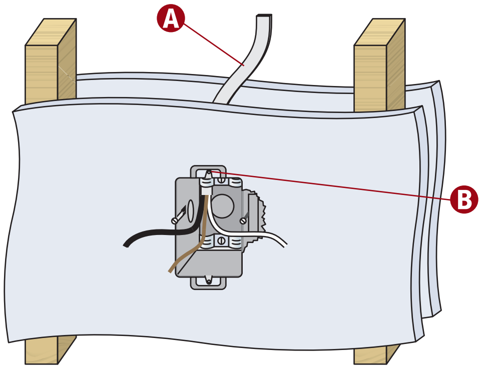
Mounting Enclosures in Finished Surfaces

A No support or securing is required where the cable is fished between access points, concealed in the finished surface, and where such supporting of the cable is impractical. Provisions are found in 320.30(D)(1) for armored cable support, in 330.30(D)(1) for metal-clad cable support, and in 334.30(B)(1) for nonmetallic-sheathed cable support.

B An enclosure mounted in a finished surface must be rigidly secured to the surface by clamps, anchors, or fittings identified for the application »*314.23(C)*«.

Note

No support is required for unbroken lengths (without coupling) of electrical metallic tubing (EMT) that is fished between access points, concealed in the finished surface, and where such securing of the raceway is impractical ***»358.30(A) Exception No. 2«***.



Enclosures in Suspended Ceilings

A Raceways shall not be supported by ceiling grid support wires. Raceways can be secured to independent (additional) support wires that are secured at both ends »*300.11(B)*«.

B An enclosure mounted in a suspended ceiling system shall be fastened to framing members by mechanical means (bolts, screws, rivets, clips, etc.) identified for use with the enclosure(s) and ceiling framing member(s) employed. The framing members shall be supported in an approved manner and securely fastened to each other as well as to the building structure »*314.23(D)(1)*«.

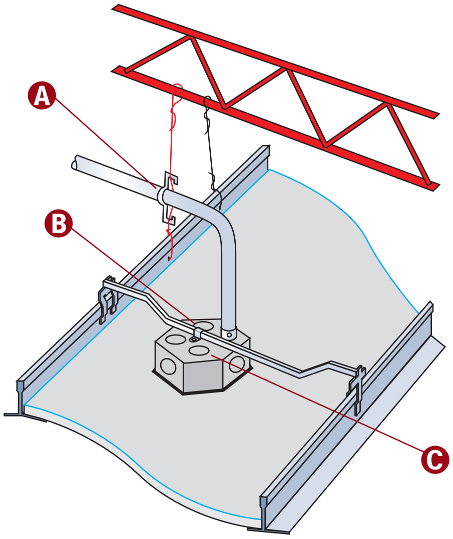
C An enclosure mounted to structural or supporting elements of a suspended ceiling shall not be more than 100 in.^{3} (1650 mm^3) in size »*314.23(D)*«.

Caution

See 300.11(B)(1) and (B)(2) for wiring located within the cavity of a fire-rated and non-fire-rated floor–ceiling (or roof–ceiling) assembly.

Note

Boxes can be secured to independent (additional) support wires that are attached at both ends ***»300.11(B)«***.



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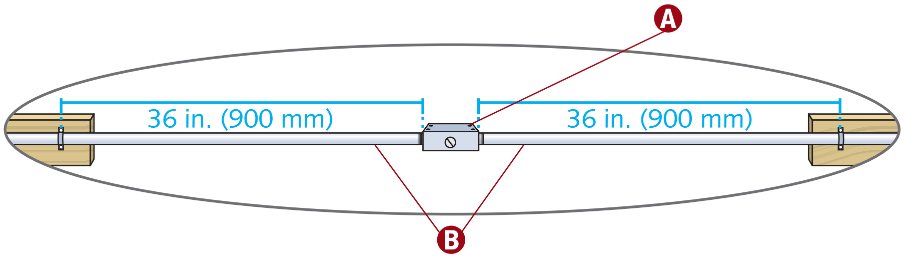
Enclosures (without Device, Luminaires, or Lampholders) Supported by Raceways

A An enclosure that does not contain device(s), other than splicing devices, and does not support luminaire(s), a lampholder, or other equipment can be supported by entering raceways when *all* of the following conditions are met: (1) the enclosure does not exceed 100 in.^{3} (1650 cm^3) size; (2) the enclosure has threaded entries or identified hubs; (3) the enclosure is supported by two or more conduits threaded wrenchtight into the enclosure or hubs; and (4) each conduit is secured within 36 in. (900 mm) of the enclosure, unless all entries are on the same side »*314.23(E)*«.

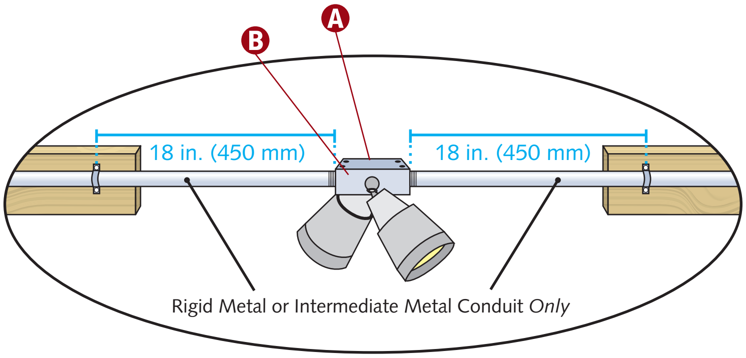
B Only rigid or intermediate metal conduit with threaded ends are permitted in 314.23(E).



Enclosures (with Devices, Luminaires, or Lampholders) Supported by Raceways

A An enclosure that contains devices (other than splicing devices) or supports luminaires, lampholders, or other equipment can be supported by entering raceways when *all* of the following conditions are met: (1) the enclosure does not exceed 100 in.^{3} (1650 cm^3) in size; (2) the enclosure has threaded entries or identified hubs; (3) the enclosure is supported by two or more conduits threaded wrenchtight into the enclosure or hubs; and (4) each conduit is secured within 18 in. (450 mm) of the enclosure »*314.23(F)*«.

B An outlet box can support a luminaire weighing 50 pounds (23 kg) or less, unless the outlet box is listed and marked on the interior of the box to indicate the maximum weight the box shall be permitted to support »*314.27(A)(2)*«.



Enclosures with Conduit Entries on One Side

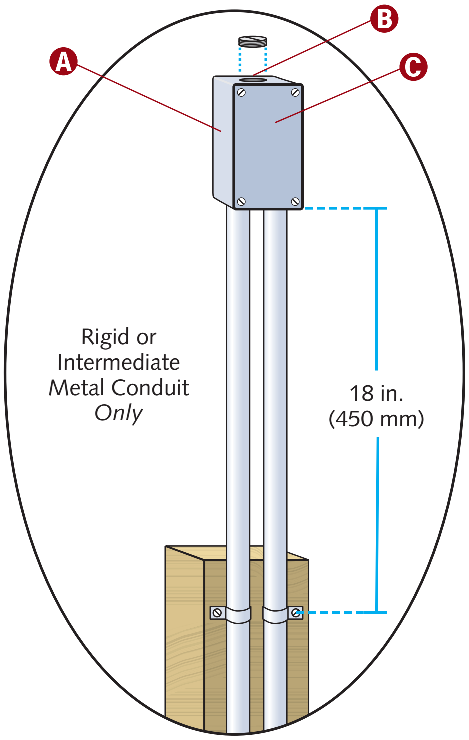
A An enclosure can be supported by conduits entering on the same side when *all* of the following conditions are met: (1) the enclosure does not exceed 100 in.^{3} (1650 cm^3) in size; (2) the enclosure has threaded entries or identified hubs; (3) the enclosure is supported by two or more conduits threaded wrenchtight into the enclosure or hubs; and (4) each conduit is secured within 18 in. (450 mm) of the enclosure »*314.23(E)*«.

B Unused cable or raceway openings, other than those intended for the operation of equipment, those intended for mounting purposes, or those permitted as part of the design for listed equipment, must be closed so that the protection provided is at least equal to that provided by the wall of the equipment »*110.12(A)*«.

C Boxes must be supported within 18 in. (450 mm), whether or not they contain devices or support fixtures, if all the conduits enter on the same side, unless the requirements of 314.23(F) Exception No. 2 are met.

Note

Boxes shall not be supported by one conduit unless the requirements of ***314.23(F) Exception No. 2*** are met.



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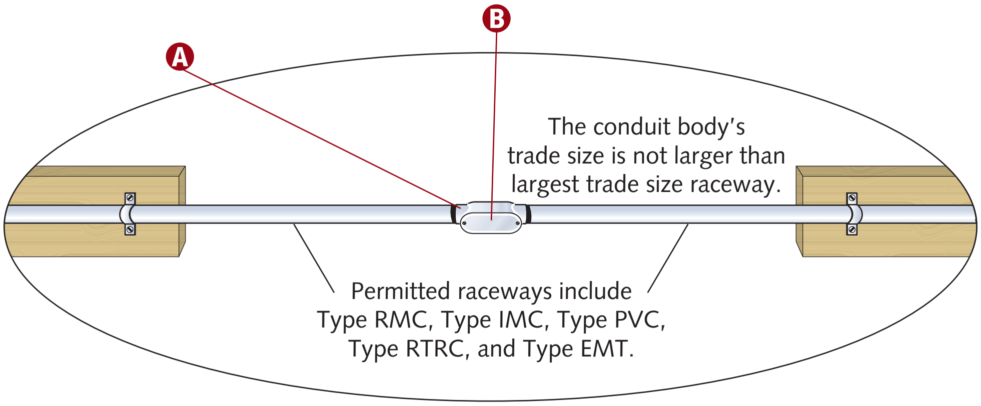
Support for Conduit Bodies

A Any size conduit body not containing a device(s), luminaire(s), lampholder(s), or other equipment can be supported by rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit, reinforced thermosetting resin conduit, or electrical metallic tubing, provided the conduit body's trade size is no larger than the largest trade size of the supporting raceway »*314.23(E) Exception*«.

B Conduit body support must be rigid and secure »*314.16(C)(2)*«.


A
B
The conduit body's trade size is not larger than largest trade size raceway.
Permitted raceways include Type RMC, Type IMC, Type PVC, Type RTRC, and Type EMT.

Note

A raceway supported conduit body that contains a device(s), luminaire(s), lampholder(s), or other equipment must be supported by either rigid metal or intermediate metal conduit only. The trade size of the conduit body must not be larger than the largest trade size of the supporting raceway ***»314.23(F) Exception No. 1«***.

The only conduit body not requiring two support raceways is a conduit body constructed with only one conduit entry ***»314.23(E) Exception«***.

Supporting Luminaires Using Lengths of Conduit Longer than 18 in.

A Section 314.23(F) Exception No. 2 permits unbroken length(s) of rigid or intermediate metal conduit to support a box used for luminaire or lampholder support or to support a wiring enclosure within a luminaire where all of the following conditions are met:

B The length of conduit extending beyond the last point of securely fastened support does not exceed 3 ft (900 mm).

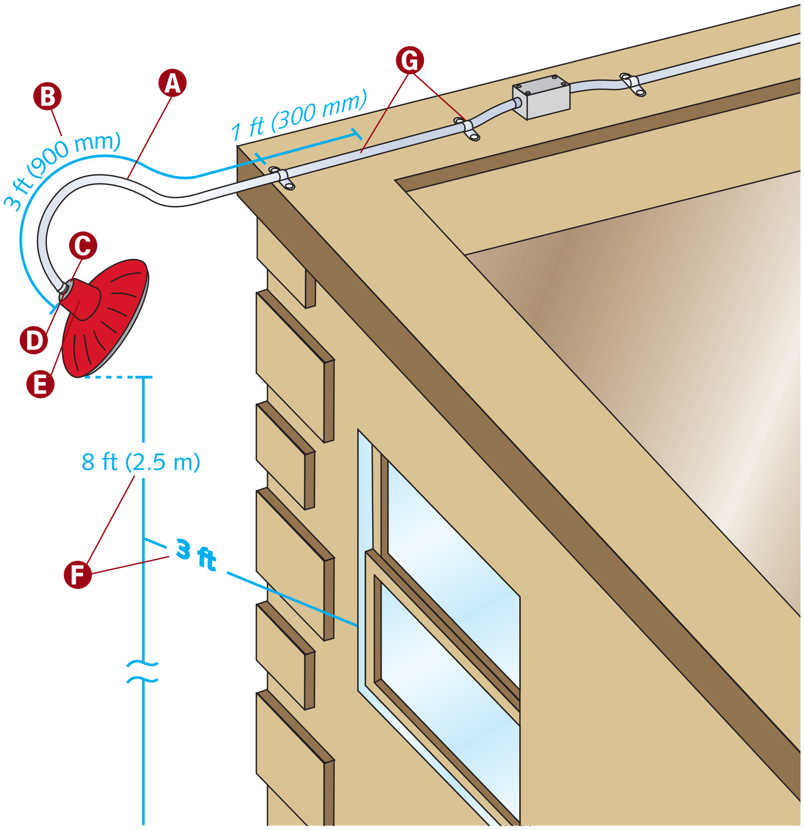
C A luminaire supported by a single conduit does not exceed 12 in. (300 mm), in any direction, from the point of conduit entry.

D The weight supported by any single conduit shall not exceed 20 pounds (9 kg).

E At the luminaire end, each conduit (if more than one) is threaded wrenchtight into the box or wiring enclosure or into identified hubs.

F Where accessible to unqualified persons, the luminaire's lowest point is at least 8 ft (2.5 m) abovegrade (or standing area) and at least 3 ft (900 mm) [measured horizontally to the 8 ft (2.5 m) elevation] from windows, doors, porches, fire escapes, or similar locations.

G The unbroken conduit before the last point of support is 12 in. (300 mm) or greater and that portion of the conduit is securely fastened not less than 12 in. (300 mm) from its last point of support.



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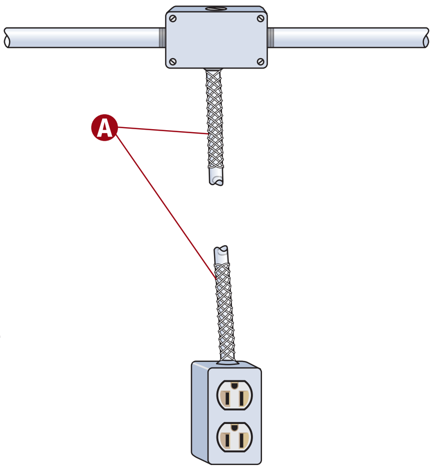
Strain Relief for Flexible Cords

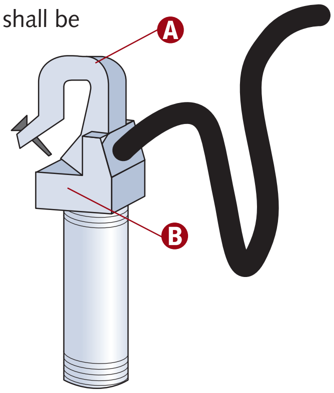
A Multiconductor cord or cable used to support a box must be protected in an approved manner so that the conductors are not subjected to strain. A strain-relief connector threaded into a box with a hub would be acceptable »*314.23(H)(1)*«.



Luminaire Hanger

A Section 314.27(A)(2) requires an independent support, such as a luminaire hanger, for luminaires that weigh more than 50 pounds (23 kg) unless the outlet box is listed and marked on the interior of the box to indicate the maximum weight the box shall be permitted to support.

B When raceway fittings are used to support luminaire(s), they must be capable of supporting the combined weight of the luminaire assembly and lamp(s) »*410.36(E)*«.



Conduit Stems Supporting Luminaires

A An outlet box used exclusively for lighting shall be designed or installed so that a luminaire or lampholder may be attached. Boxes must be able to support a luminaire weighing at least 50 pounds (23 kg). A luminaire that weighs more than 50 pounds (23 kg) shall be supported independently of the outlet box, unless the outlet box is listed for not less than the weight to be supported. The interior of the box shall be marked by the manufacturer to indicate the maximum weight the box shall be permitted to support »*314.27(A)(2)*«.

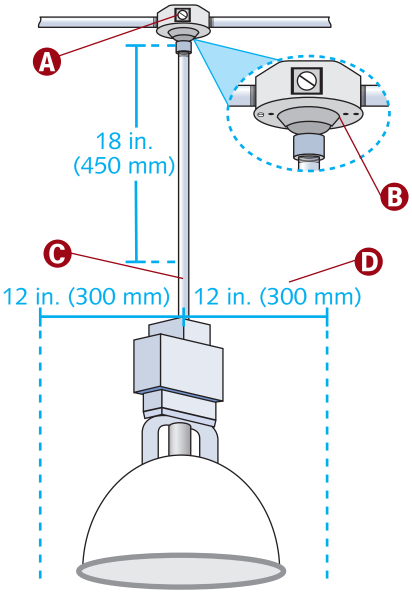
B Stems longer than 18 in. (450 mm) shall be connected to the wiring system with listed swivel hangers suitable for the location. At the luminaire end, the conduit(s) shall be threaded wrenchtight into the box or wiring enclosure or into identified hubs »*314.23(H)(2)*«.

C A box supporting lampholders, luminaires, or wiring enclosures within luminaires used in lieu of boxes in compliance with 300.15(B) must be supported by rigid or intermediate metal conduit stems »*314.23(H)(2)*«.

D A luminaire supported by a single conduit shall not exceed 12 in. (300 mm) in any horizontal direction from the point of conduit entry »*314.23(H)(2)*«.

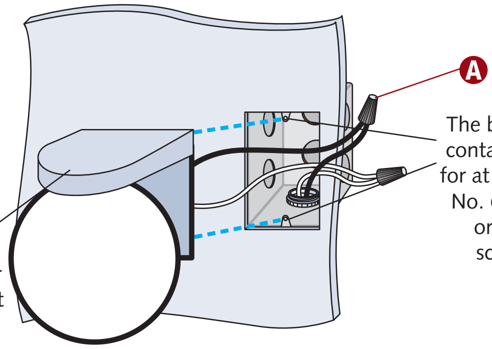
Caution

Any point of a luminaire supported by a single conduit must be at least 8 ft (2.5 m) abovegrade (or standing area) and at least 3 ft (900 mm) (measured horizontally to the 8 ft [2.5 m] elevation) from windows, doors, porches, fire escapes, or similar locations, unless an effective means to prevent the threaded joint from loosening (such as a set screw) is used »*314.23(H)(2)*«.



Device Boxes Supporting Luminaires or Lampholders

A A vertically mounted luminaire or lampholder weighing no more than 6 pounds (3 kg) can be supported by boxes (such as device boxes) not specifically designed to support luminaires or lampholders, provided the luminaire or its supporting yoke, or the lampholder, is secured to the box with at least two No. 6 or larger screws. Plaster rings, secured to other boxes, are also acceptable »*314.27(A)(1) Exception*«.



The box must contain holes for at least two No. 6 (6/32) or larger screws.

The luminaire or lampholder must not weigh over 6 pounds (3 kg).

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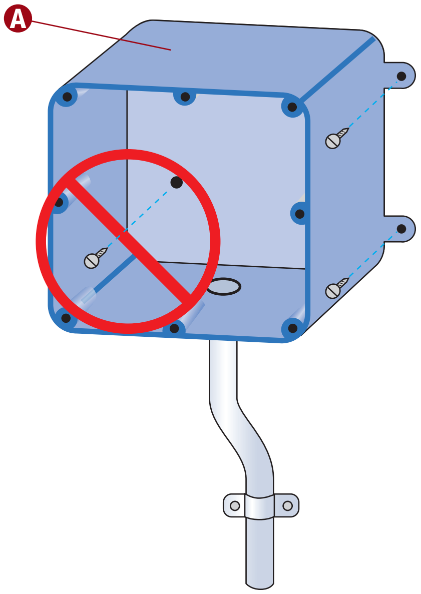
Mounting Nonmetallic Boxes

A Supporting screws for nonmetallic boxes must be mounted outside of the box, unless the box is constructed in a manner that prevents contact between the conductors in the box and the supporting screws »*314.103*«.



Note

Approved drainage openings not smaller than ⅛ in. (3 mm) and not larger than ¼ in. (6 mm) in diameter shall be permitted to be installed in the field in boxes or conduit bodies listed for use in damp or wet locations. For installation of listed drain fittings, larger openings are permitted to be installed in the field in accordance with manufacturer's instructions ***»314.15«***.

Luminaire Outlet Boxes

A Boxes used at luminaire or lampholder outlets in a ceiling must be designed for the purpose and shall be required to support a luminaire weighing a minimum of 50 pounds (23 kg). Every box used exclusively for lighting must be designed and installed so that a luminaire or lampholder may be attached »*314.27(A)(2)*«.

B A luminaire that weighs more than 50 lb (23 kg) shall be supported independently of the outlet box, unless the outlet box is listed for not less than the weight to be supported. The interior of the box shall be marked by the manufacturer to indicate the maximum weight the box shall be permitted to support »*314.27(A)(2)*«.

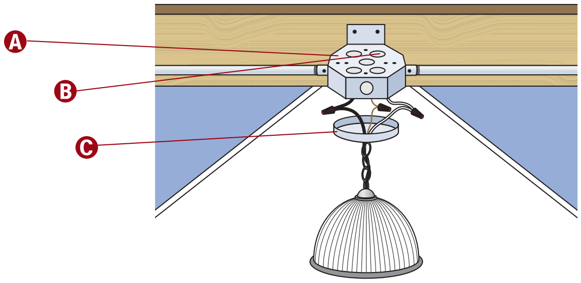
C Inspection of the connections between luminaire conductors and circuit conductors must be possible without having to disconnect any part of the wiring (unless the luminaires are connected by attachment plugs and receptacles) »*410.8*«.

Note

Typically, two No. 8 (8/32) screws are used to attach a luminaire or its supporting yoke to an outlet box.

Note

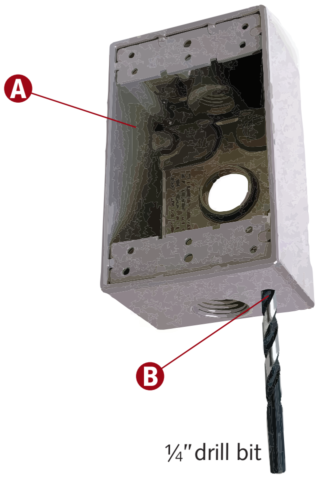
Boxes used at luminaire or lampholder outlets in or on a vertical surface shall be identified and marked on the interior of the box to indicate the maximum weight of the luminaire that is permitted to be supported by the box if other than 50 lb (23 kg) ***»314.27(A)(1)«***.



Drainage Openings

A In damp or wet locations, boxes, conduit bodies, outlet box hoods, and fittings shall be placed or equipped so as to prevent moisture from entering or accumulating within the box, conduit body, or fitting. Boxes, conduit bodies, outlet box hoods, and fittings installed in wet locations shall be listed for use in wet locations »*314.15*«.

B Approved drainage openings not smaller than ⅛ in. (3 mm) and not larger than ¼ in. (6 mm) in diameter shall be permitted to be installed in the field in boxes or conduit bodies listed for use in damp or wet locations. For installation of listed drain fittings, larger openings are permitted to be installed in the field in accordance with manufacturer's instructions »*314.15*«.



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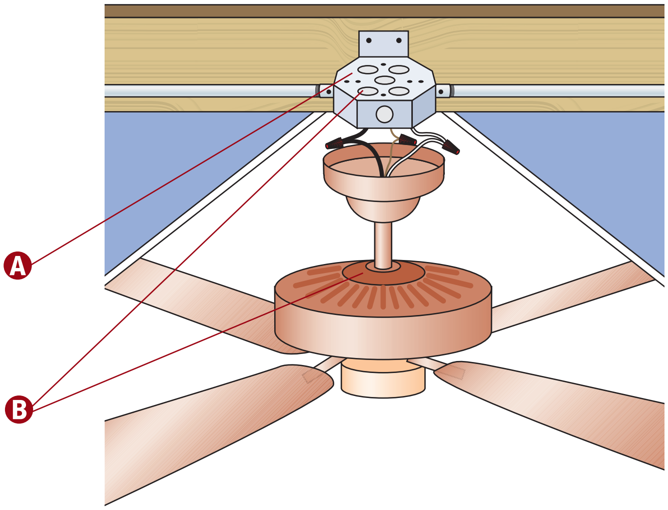
Ceiling-Suspended (Paddle) Fan Boxes

A An outlet box or outlet box system shall not be used as the sole means of support for a ceiling-suspended (paddle) fan unless the box is (1) listed, (2) marked by the manufacturer as suitable for the purpose, and (3) supporting a ceiling-suspended (paddle) fan weighing 70 pounds (32 kg) or less. For outlet boxes or outlet box systems designed to support ceiling-suspended (paddle) fans weighing more than 35 pounds (16 kg), the required marking must include the maximum weight that can be supported »*314.27(C)*«.

B Ceiling-suspended (paddle) fans must be supported independently of an outlet box, unless the listed outlet box or outlet box system is identified for the use and installed in accordance with 314.27(C) or a listed weight-supporting ceiling receptacle and a compatible factory-installed weight-supporting attachment fitting that is installed in accordance with 314.27(E) »*422.18*«.



Caution

Outlet boxes mounted in the ceilings of habitable rooms of dwelling occupancies in a location acceptable for the installation of a ceiling-suspended (paddle) fan, must either:
1) be listed for the sole support of ceiling-suspended (paddle) fans, or
2) be an outlet box complying with the applicable requirements of 314.27 and providing access to structural framing capable of supporting of a ceiling-suspended (paddle) fan bracket or equivalent »***314.27(C)***«.

Junction and Pull Box Sizing

Straight Pull—Two Raceways

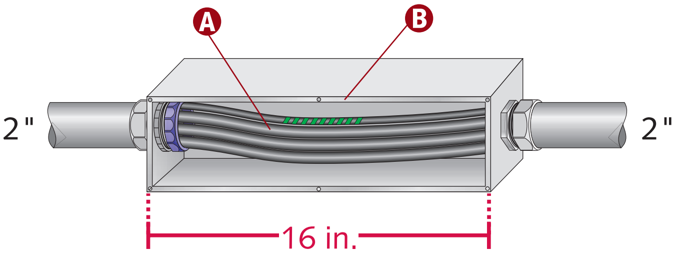
Section 314.16 is used to determine box size requirements for 6 AWG and smaller conductors. Calculations are based on the sizes and numbers of *conductors*. Section 314.28 is used to determine the box size requirements for 4 AWG and larger conductors (1000 volts or less). Calculations here are based on the sizes and numbers of *raceways*.

A Box calculations for 4 AWG and larger conductors (1000 volts or less) are performed based on the size and numbers of raceways »*314.28*«.

B Boxes or conduit bodies containing straight pulls are sized according to the largest raceway entering the box. The length must be at least eight times the trade size (metric designator) of the largest raceway »*314.28(A)(1)*«.

Note

Use the trade dimension that is applicable to the installation. For example, if millimeters or centimeters are needed to size the junction or pull box, use the metric designator in millimeters instead of the trade size in inches. A junction box is needed for a straight pull with two metric designator 53 raceways. (A 2-in. trade size raceway has a metric designator of 53 mm.) Calculate the minimum length by multiplying the metric designation by eight (53 mm × 8 = 424 mm = 42.4 cm). The minimum size pull box required is 424 mm or 42.4 cm.



Straight Pull

2 (trade size of largest raceway) x 8 = 16 in.

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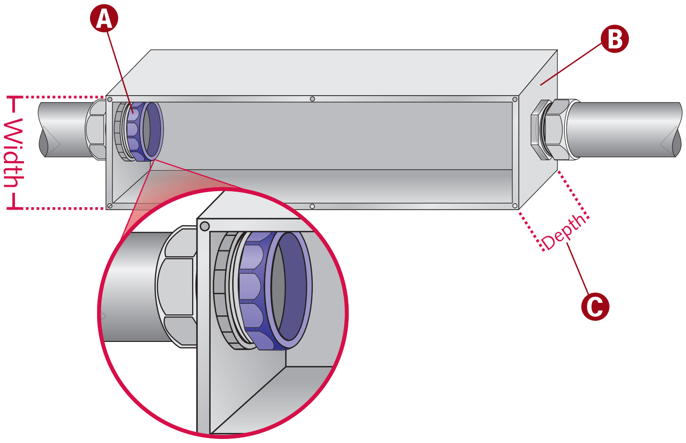
Width and Depth of the Box

Ⓐ The box width must be large enough to provide proper installation of the raceway or cable, including locknuts and bushings.

Ⓑ The box depth must be large enough to provide proper installation of the raceway or cable, including locknuts and bushings.

Ⓒ No requirement specifies the depth of the box, unless a raceway enters the back of the box.



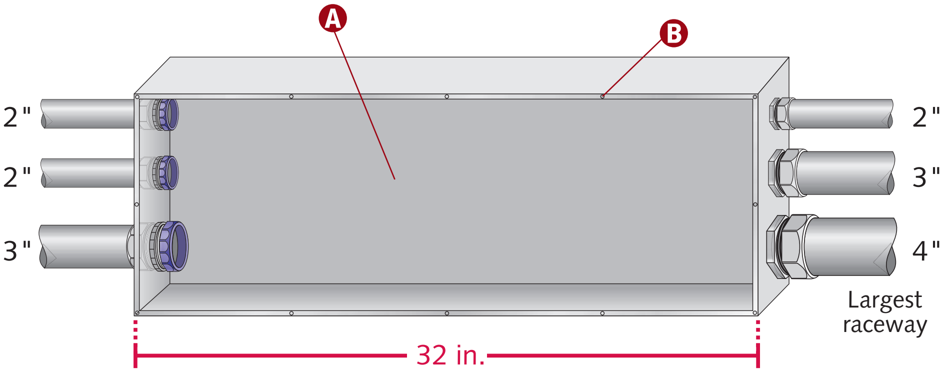
Straight Pull—Multiple Raceways

Ⓐ The length must be at least eight times the trade size (metric designator) of the largest single raceway. No extra space is required for additional raceways when calculating the minimum length of straight pulls. However, additional space is needed for the width of additional raceways, including locknuts and bushings »*314.28(A)(1)*«.

Ⓑ Conduit bodies and boxes (junction, pull, and outlet) must be installed so that the wiring they contain can be made accessible without removing any part of the building or structure »*314.29*«.

Caution

Except as permitted in 250.112(l), all metal boxes shall be grounded and bonded in accordance with Parts I, IV, V, VI, VII, and X of Article 250 as applicable »***314.4***«.



Straight Pull

4 (trade size of largest raceway) x 8 = 32 in.

Note

Underground boxes and handhole enclosures shall be installed so they are accessible without excavating sidewalks, paving, earth, or other substance that is to be used to establish the finished grade. Exception: Listed boxes and handhole enclosures shall be permitted where covered by gravel, light aggregate, or noncohesive granulated soil if their location is effectively identified and accessible for excavation »***314.29(B)* and *Exception***«.

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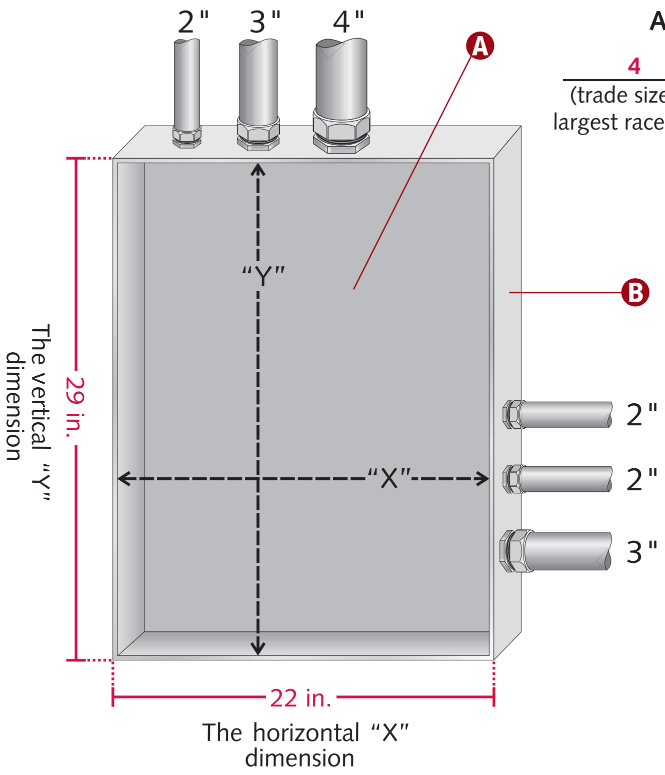
Angle or U Pulls (or Splices)—Multiple Raceways

A Where splices or where angle or U pulls are made, the distance between each raceway entry into the box and the opposite wall must be at least six times the trade size (metric designator) of the largest raceway in a row. This distance is increased for additional raceway entries (in the same row on the same wall of the box) by the sum of the diameters of all other raceway entries »*314.28(A)(2)*«.

B To calculate the dimension of a box with angle pulls, start with one wall where the raceways enter the box, and find the distance to the opposite wall of the box. The path of the conductors is irrelevant to this calculation.

C Pick one wall and multiply the largest raceway (trade diameter) by 6. Add to that number the trade diameter of all other raceway(s) in the same row, on the same side of the box.



Angle Pull for "Y" Dimension

4 (trade size of largest raceway) x 6 + 3 + 2 (all other raceways in the same row, on the same wall) = 29 in.

C

Angle Pull for "X" Dimension

3 (trade size of largest raceway) x 6 + 2 + 2 (all other raceways in the same row, on the same wall) = 22 in.

Caution

Where a box contains both straight and angle (or U) pulls, or straight pulls and splices, calculate each type of pull individually to find the dimension. Always select the largest dimensions.

Note

All pull boxes, junction boxes, and conduit bodies must have covers that are compatible with the box or conduit body construction and must be suitable for the conditions of use. Where used, metal covers shall comply with the grounding requirements of 250.110 »*314.28(C)*«.

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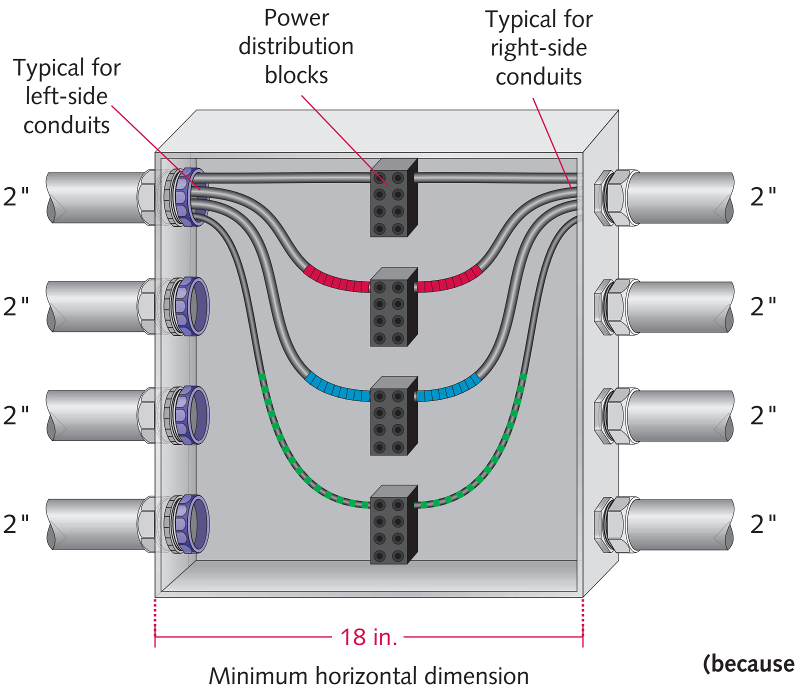
Power Distribution Blocks

Where a junction or pull box contains 4 AWG or larger conductors and power distribution blocks for connections of conductors, the box must be over 100 in.^{3} (1650 cm^3) and comply with the size requirements of 314.28(A)(2). The box shall not be smaller than specified in the installation instructions of the power distribution block. Wire bending space at the terminals of the power distribution blocks must comply with 312.6. The power distribution blocks shall be listed and not have uninsulated live parts exposed within the box, whether or not the box cover is installed. Where conductors pass through the box and do not terminate on the power distribution block, the through conductors shall be arranged so the power distribution block terminals are unobstructed following installation »*314.28(E)*«.


Typical for left-side conduits
Power distribution blocks
Typical for right-side conduits
2"
2"
2"
2"
2"
2"
2"
2"
18 in.
Minimum horizontal dimension

Horizontal Dimension
(because of the power distribution blocks)

$$\underbrace{2}_{\text{(trade size of largest raceway)}} \times 6 + \underbrace{2 + 2 + 2}_{\text{(all other raceways in the same row, on the same wall)}} = \underline{18}\ \text{in.}$$

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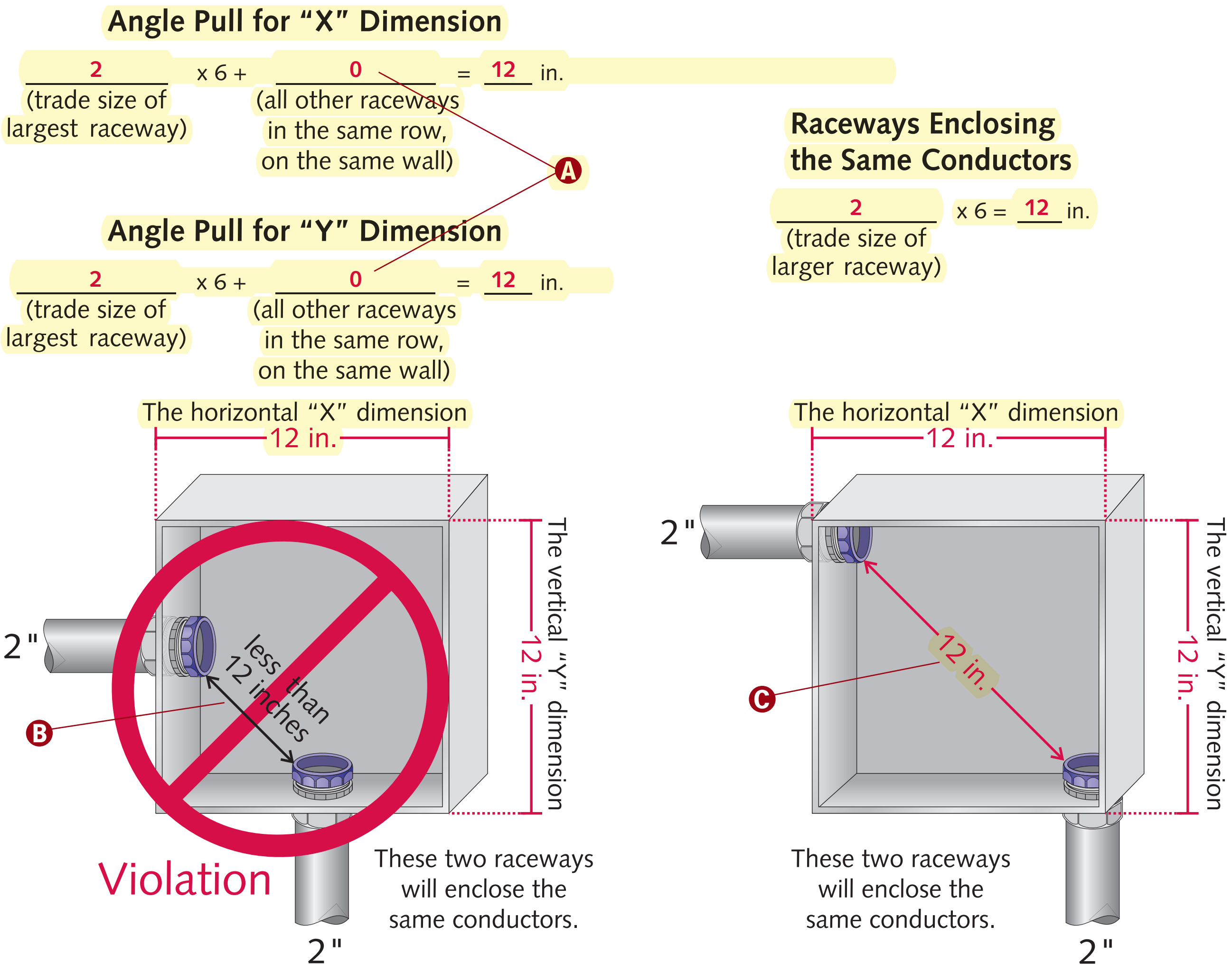
Raceways Enclosing the Same Conductors

The distance between raceway entries enclosing the same conductor shall not be less than six times the trade size (metric designator) of the largest raceway »*314.28(A)(2)*«. This provision is applicable even if the raceway entries are on different walls.

A Because no other raceways enter on the same wall of the box, no additional raceway diameters are added.

B The minimum dimension required for this box is 12 in. × 12 in. The distance between the raceway entries must not be less than six times the trade size of the larger raceway. Because each raceway is located in the center of the wall of the box, the distance between the raceway entries is less than 12 in. Therefore, this installation is not permitted.

C This 12 in. × 12 in. junction (or pull) box is permitted if the raceways can be installed so the distance between the raceway entries is at least 12 in. Because the distance between the raceway entries is 12 in., this installation is permitted.


Angle Pull for "X" Dimension
2 x 6 + 0 = 12 in.
(trade size of largest raceway)
(all other raceways in the same row, on the same wall)
A
Angle Pull for "Y" Dimension
2 x 6 + 0 = 12 in.
(trade size of largest raceway)
(all other raceways in the same row, on the same wall)
Raceways Enclosing the Same Conductors
2 x 6 = 12 in.
(trade size of larger raceway)
The horizontal "X" dimension
12 in.
The vertical "Y" dimension
12 in.
2"
less than 12 inches
B
Violation
2"
These two raceways will enclose the same conductors.
The horizontal "X" dimension
12 in.
2"
12 in.
C
The vertical "Y" dimension
12 in.
These two raceways will enclose the same conductors.
2"

Conductors in these boxes will be larger than 6 AWG.

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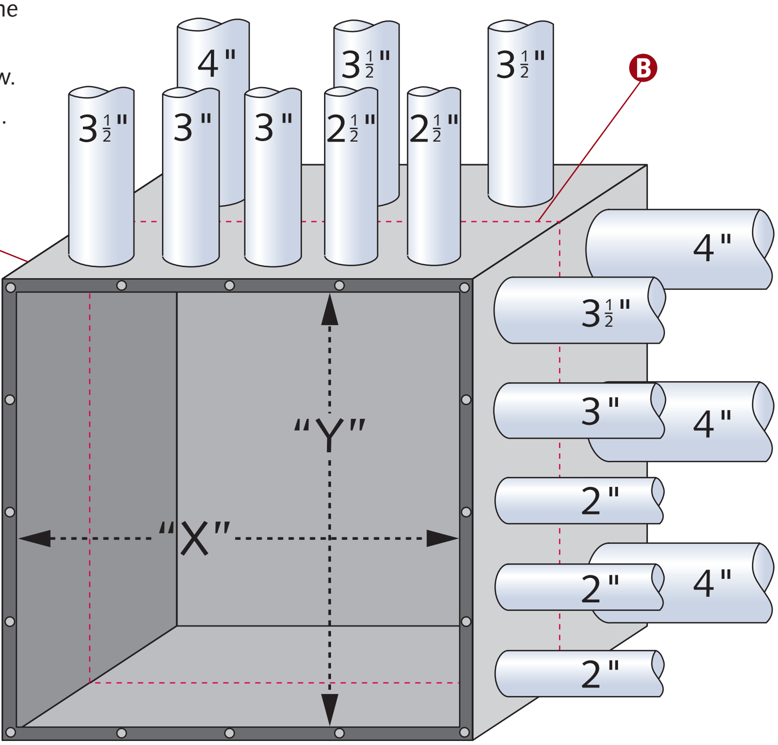
Angle Pull—Multiple Rows

A Where multiple rows of raceways enter a box, calculate each row separately. Use the single row that provides the maximum distance »*314.28(A)(2)*«.

B Create an imaginary divider line separating each row.

C Perform each row calculation as if in a separate box.



Angle Pull for "Y" Dimension (Back Row)

$$\underset{\text{(trade size of largest raceway)}}{\underline{4}} \times 6 + \underset{\text{(all other raceways, in the same row, on the same wall)}}{\underline{3\tfrac{1}{2} + 3\tfrac{1}{2}}} = \underline{31}\text{ in.}$$

Angle Pull for "Y" Dimension (Front Row)

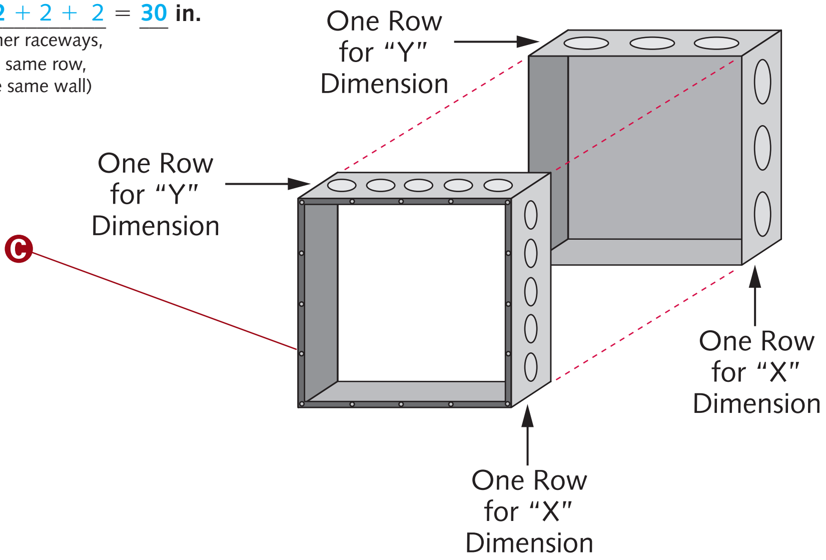
$$\underset{\text{(trade size of largest raceway)}}{\underline{3\tfrac{1}{2}}} \times 6 + \underset{\text{(all other raceways, in the same row, on the same wall)}}{\underline{3 + 3 + 2\tfrac{1}{2} + 2\tfrac{1}{2}}} = \underline{32}\text{ in.}$$

Angle Pull for "X" Dimension (Back Row)

$$\underset{\text{(trade size of largest raceway)}}{\underline{4}} \times 6 + \underset{\text{(all other raceways, in the same row, on the same wall)}}{\underline{4 + 4}} = \underline{32}\text{ in.}$$

Angle Pull for "X" Dimension (Front Row)

$$\underset{\text{(trade size of largest raceway)}}{\underline{3\tfrac{1}{2}}} \times 6 + \underset{\text{(all other raceways, in the same row, on the same wall)}}{\underline{3 + 2 + 2 + 2}} = \underline{30}\text{ in.}$$


One Row for "Y" Dimension
One Row for "Y" Dimension
C
One Row for "X" Dimension
One Row for "X" Dimension

Note

In pull or junction boxes having any dimension over 6 ft (1.8 m), all conductors shall be cabled (or racked) in an approved manner »***314.28(B)***«.

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U Pull—Two Raceways

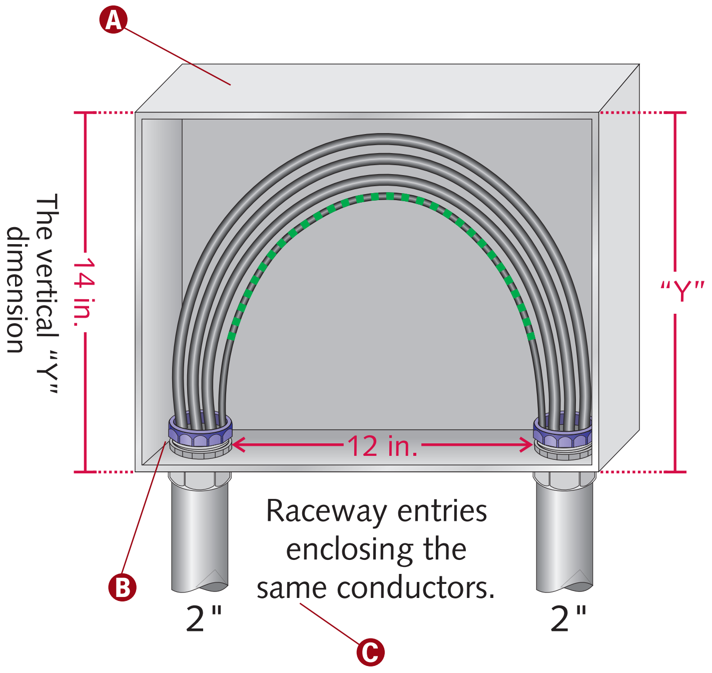
Ⓐ Use the angle pull method to calculate U pulls. A box with conduit entries only on one wall has a minimum distance to the opposite wall. Multiply the largest raceway by six and add the sum of the trade size (metric designator) of the other raceway(s) entering the same wall »*314.28(A)(2)*«.

Ⓑ The minimum box width must include 12 in. between raceways plus the thickness of the two raceways (including enough area to provide proper installation of locknuts and bushings).

Ⓒ The distance between raceways enclosing the same conductor(s) must be at least six times the trade size (metric designator) of the largest raceway »*314.28(A)(2)*«.

Note

Where raceways contain 4 AWG or larger insulated conductors and these conductors enter a cabinet, a box, an enclosure, or a raceway, the conductors must be protected by: an identified fitting providing a smoothly rounded insulating surface; or a listed metal fitting that has smoothly rounded edges; or separation from the fitting or raceway by using an identified insulating material that is securely fastened in place (such as a plastic bushing); or threaded hubs or bosses that are an integral part of the enclosure providing a smoothly rounded or flared entry for conductors ***»300.4(G)«***.



Ⓐ
The vertical "Y" dimension
14 in.
"Y"
12 in.
Ⓑ
Raceway entries enclosing the same conductors.
2"
2"
Ⓒ

U Pull for "Y" Dimension

2 (trade size of largest raceway) x 6 + 2 (all other raceways in the same row, on the same wall) = 14 in.

Raceways Enclosing the Same Conductors

2 (trade size of larger raceway) x 6 = 12 in.

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Raceways Entering Opposite Removable Covers

Ⓐ Where angle pulls are made, the distance between each raceway entry into the box and the opposite wall of the box must be at least six times the trade size (metric designator) of the largest raceway »*314.28(A)(2)*«. Where no other raceways enter the same wall of the box, no additional raceway diameters are added.

Ⓑ Where a raceway or cable enters the wall of a box (or conduit body) opposite a removable cover, the distance from the entry wall to the cover can be determined by the distance requirements for one wire per terminal found in Table 312.6(A) »*314.28(A)(2) Exception*«.

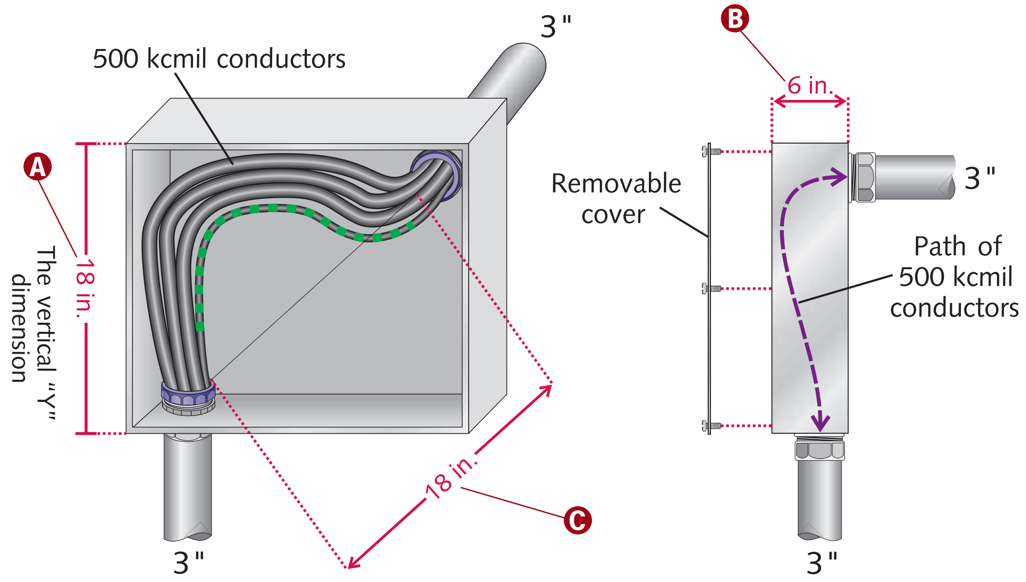
Ⓒ The minimum distance between raceways enclosing the same conductor(s) is six times the trade size (metric designator) of the largest raceway »*314.28(A)(2)*«.

Note

Table 312.6(A) also includes a column that can be used to determine the minimum wire-bending space for compact stranded aluminum conductors in sizes up to 1000 kcmil and manufactured using AA-8000 series electrical-grade aluminum alloy conductor material in accordance with 310.3(B).

Raceways or Cables Entering Boxes Opposite from Removable Covers

Wire Size (AWG or kcmil)	***Minimum Distance from Wall to Cover***	
	in.	***mm***
4–3	2	50.8
2	2½	63.5
1	3	76.2
1/0–2/0	3½	88.9
3/0–4/0	4	102
250	4½	114
300–350	5	127
400–500	6	152
600–700	8	203
750–900	8	203
1000–1250	10	254
1500–2000	12	305



Front View

Side View

Angle Pull for "Y" Dimension

3 (trade size of largest raceway) x 6 + 0 (all other raceways in the same row, on the same wall) = 18 in.

Raceways Enclosing the Same Conductors

3 (trade size of larger raceway) x 6 = 18 in.

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Boxes and Conduit Bodies Not Meeting 314.28 and Chapter 9

Ⓐ Listed boxes or listed conduit bodies of dimensions less than those required in 314.28(A)(1) and (A)(2) shall be permitted for installations of combinations of conductors that are less than the maximum conduit or tubing fill (of conduits or tubing being used) permitted by Table 1 of Chapter 9 »*314.28(A)(3)*«.

Ⓑ Listed conduit bodies of dimensions less than those required in 314.28(A)(2), and having a radius of the curve to the centerline not less than that indicated in Table 2 of Chapter 9 for one-shot and full-shoe benders, shall be permitted for installations of combinations of conductors permitted by Table 1 of Chapter 9. These conduit bodies shall be marked to show they have been specifically evaluated in accordance with this provision.

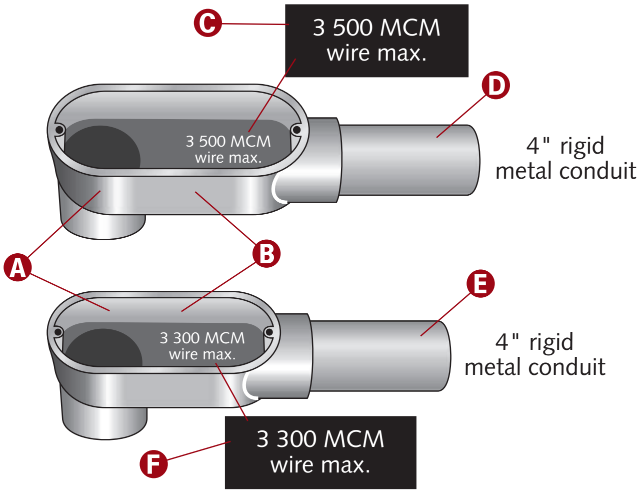
Where the permitted combinations of conductors for which the box or conduit body has been listed are less than the maximum conduit or tubing fill permitted by Table 1 of Chapter 9, the box or conduit body shall be permanently marked with the maximum number and maximum size of conductors permitted. For other conductor sizes and combinations, the total cross-sectional area of the fill shall not exceed the cross-sectional area of the conductors specified in the marking, based on the type of conductor identified as part of the product listing.

Ⓒ Three 500 kcmil conductors are the maximum number and size permitted in this conduit body.

Ⓓ By comparison, the maximum number of 500 kcmil THHN conductors permitted in 4-inch rigid metal conduit is seven.

Ⓔ By comparison, the maximum number of 300 kcmil THHN conductors permitted in a 4-inch rigid metal conduit is eleven.

Ⓕ Three 300 kcmil conductors are the maximum number and size permitted in this conduit body.



Warning

Conduit bodies do not have to be large enough to contain the same size and number of conductors permitted in the raceway that enters the conduit body.

Caution

Listed or labeled equipment shall be installed and used in accordance with any instructions included in the listing or labeling »*110.3(B)*«.

Note

Smaller-size conduit bodies can generally hold the same number and sizes of conductors (6 AWG and smaller) as the raceway entering the conduit body.

Note

If a conduit body is durably and legibly marked by the manufacturer with the volume, it can contain splices, taps, or devices »***314.16(C)(2)***«.

Summary

- Limitations apply to the size and number of conductors permitted in boxes (junction, pull, etc.) and conduit bodies.
- One strap (yoke) counts as two of the largest conductors connected to the device.
- Nonmetallic boxes may list the maximum number of conductors permitted in the box, but that number must be reduced if switches, receptacles, etc. are installed in the box.
- Plaster rings, raised covers, extension rings, etc. can provide additional cubic-inch capacity to boxes.
- Conduit bodies can contain splices, taps, or devices if the conduit body is durably and legibly marked by the manufacturer with the volume.
- The minimum length of free conductor (6 in. [150 mm]) is measured from the point in the box where it emerges from its raceway or cable sheath.
- Except as permitted in 250.112(l), all metal boxes shall be grounded and bonded in accordance with Parts I, IV, V, VI, VII, and X of Article 250 as applicable.
- Boxes and conduit bodies must remain accessible.
- In suspended ceilings, boxes can be secured by support wires that are installed in addition to the ceiling grid support wires.
- Where boxes enclose 4 AWG and larger conductors that are required to be insulated, different calculation methods apply to straight pulls than to angle pulls.

- There is a minimum distance required between raceways enclosing the same conductors (4 AWG and larger) within a pull or junction box.
- Conduit bodies may not allow the same size and number of conductors as is permitted in the conduit (or tubing) that enters the conduit body.

Unit 3 Competency Test

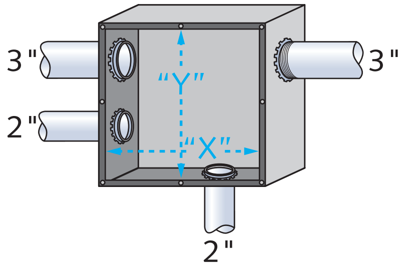
***NEC*® Reference** **Answer**

____________ ____________ 1. In pull boxes or junction boxes having any dimension over ____________ in., all conductors shall be cabled or racked up in an approved manner.

a) 6 b) 12 c) 36 d) 72

____________ ____________ 2. Boxes and conduit bodies in buildings shall be installed so the contained wiring and devices are ____________.

____________ ____________ 3. What are the minimum dimensions for “X” and “Y” in the drawing below if the conductors within the 3-in. conduit are pulled straight through the 3-in. conduit on the opposite wall and the conductors in the 2-in. conduit are pulled through the 2-in. conduit on the adjacent wall? All conductors are 4 AWG and larger.



____________ ____________ 4. Outlet boxes that do not enclose devices or utilization equipment shall have a minimum internal depth of ____________ in.

____________ ____________ 5. A $4\frac{11}{16}$-in. square box that is 2⅛ in. deep already contains two receptacles, two internal cable clamps, four 12 AWG THHN copper conductors (two black and two white), two grounding conductors, three wire nuts, two pigtails, and one equipment bonding jumper. (A flat plaster ring was used to secure the receptacles to the box.) How many more 12 AWG THHN copper conductors can be added to this box?

____________ ____________ 6. In damp or wet locations, surface-type enclosures (within the scope of Article 312) shall be so placed or equipped as to prevent moisture or water from entering and accumulating within the cabinet or cutout box and shall be mounted so there is at least ____________ in. airspace between the enclosure and the wall or other supporting surface.

____________ ____________ 7. The minimum thickness in inches for a steel box measuring 6 in. × 4 in. × 3½ in. is ____________ in.

____________ ____________ 8. Covers of outlet boxes and conduit bodies having holes through which flexible cord pendants may pass shall be provided with approved ____________ or shall have smooth, well-rounded surfaces on which the cord may bear.

____________ ____________ 9. A weatherproof metal junction box measuring 4 in. × 4 in. × 6 in. has been installed to support a luminaire. Two rigid metal conduits have been threaded wrenchtight into the threaded entries of the enclosure. The box has not yet been secured to the brick wall, but both conduits have been strapped to the wall 16 in. from the box. What additional support (from the following list) is required for this box?

I. Two metal screws with plastic anchors
II. Two toggle bolts
III. Two drive pins

a) none b) I or II only c) I or III only d) I, II, or III

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NEC® Reference	Answer	
___________	___________	10. Where permanent barriers are installed in a junction box, each section shall be considered as a(n) ___________.
___________	___________	11. What is the maximum number of 12 AWG THW conductors permitted in a 4-in. octagon box that is 1½ in. deep? (The box contains a fixture stud and a hickey.)
___________	___________	12. A means must be provided in each metal box for the connection of a(n) ___________.
___________	___________	13. Installations within or behind a surface of concrete, tile, gypsum, plaster, or other noncombustible material, including boxes employing a flush-type cover or faceplate, shall be made so that the front edge of the box, plaster ring, extension ring, or listed extender will not be set back of the finished surface more than ___________ in.
___________	___________	14. Nonmetallic boxes shall be suitable for the lowest ___________ conductor entering the box.
___________	___________	15. An electrician needs to install a surface-mounted, nonmetallic, weatherproof cabinet on the outside of a concrete block building. Since the cabinet must be mounted in a wet location, it must be mounted so there is at least ___________ in. of airspace between the cabinet and the wall.
___________	___________	16. How many 14 AWG THW conductors are permitted in a 3 in. × 2 in. × 2½ in. device box?
___________	___________	17. Nonmetallic surface extensions must be secured in place by approved means at intervals not exceeding ___________ in.
___________	___________	18. A 2½-in. rigid metal conduit enters the back of a pull box with a removable cover on the opposite side. The raceway encloses four 4/0 AWG THHN copper conductors and one 4 AWG equipment grounding conductor. The minimum depth (distance from the entry wall to the cover) for this pull box is ___________ in.
___________	___________	19. Where nonmetallic boxes are used with open wiring or concealed knob-and-tube wiring, the conductors must enter the box through ___________.
___________	___________	20. Luminaires weighing no more than ___________ pounds can be supported by boxes (such as device boxes) not specifically designed to support luminaires, provided the luminaire, or its supporting yoke, is secured to the box with at least two No. 6 or larger screws.
___________	___________	21. For straight pulls, the length of the box shall not be less than ___________ the outside diameter, over sheath, of the largest shielded conductor entering the box if the system voltage is over 1000 volts, nominal.
___________	___________	22. Approved drainage openings not smaller than ___________ and not larger than ___________ in diameter shall be permitted to be installed in the field in boxes or conduit bodies listed for use in damp or wet locations.
___________	___________	23. Unused openings, other than those intended for the operation of equipment, those intended for mounting purposes, or those permitted as part of the design for listed equipment, shall be closed to afford protection ___________ to the wall of the equipment.
___________	___________	24. At least ___________ in. of free conductor (measured from the point in the conduit body where it emerges from its raceway or cable sheath) shall be left at each outlet, junction, and switch point.
___________	___________	25. A switch rated for 20 amps will be installed in a device box adjacent to a switch rated for 15 amps. Two 12 AWG THHN copper conductors will be terminated onto the switch rated 20 amps and two 14 AWG THHN copper conductors will be terminated onto the switch rated 15 amps. The required volume allowance for the switch rate 20 amps is ___________ in.^{3} and the required volume allowance for the switch rate 15 amps is ___________ in.^{3}

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Unit 4

Section One: Foundational Provisions

Cables

Objectives

After studying this unit, the student should be able to:

- recall that cables must be installed at least 1¼ in. (32 mm) from the edges of wood framing members, unless a steel plate (or bushing) has been installed.
- explain the requirement stating nonmetallic-sheathed cable passing through metal framing must be protected by bushings (or grommets) covering all metal edges.
- recall that openings around electrical penetrations through fire-resistant-rated construction must be sealed using approved methods to maintain the fire-resistant rating.
- determine what cables are permitted in spaces used for environmental air-handling purposes.
- explain the support requirements for MC, AC, and nonmetallic-sheathed cable.
- recall that a minimum bending radius must be maintained with cables.
- recall that cables must be protected from physical damage.
- summarize both general and specific installation provisions for MC, AC, and nonmetallic-sheathed cable.
- explain conductor identification and the permissible reidentification of certain conductors.
- clarify when grounded circuit conductors are required to be installed in device boxes that contain switches.
- explain underground installation provisions.
- explain flat conductor, integrated gas-spacer, mineral-insulated, and medium-voltage cables.

Introduction

Unit 4 contains regulations for cable systems that are used often (such as metal-clad cable and nonmetallic-sheathed cable), as well as cable systems that are used rarely (such as integrated gas-spacer cable and flat conductor cable). A key provision found in most of the cable articles (and some of the raceway articles) states that the cable (or raceway) must not be installed where subject to physical damage. Cable protection can be achieved by several methods, including installing the cable a minimum distance from the outside edge of a framing member; installing a steel plate on the wood framing member, over the cable; or installing the cable in an approved raceway system. Cables installed in attics have different provisions depending on the type of attic entrance. Minimum support distances (from box or enclosure to the first support, or between supports) are included in this unit. Conductor identification (and permissible reidentification) for cables is also presented in this unit.

The cable articles, found in Chapter 3 of the *NEC*® have sections titled "Uses Permitted" and "Uses Not Permitted." These sections (*XXX.10* and *XXX.12*) give locations (some specific) where the cable system can (or cannot) be installed. Since most of these provisions are clearly understandable, this book does not repeat much of this information. Also, be aware that state and local jurisdictions restrict the usage of certain cables in some (if not all) types of occupancies.

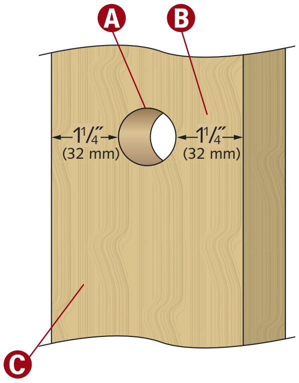
General Installation

Setback for Bored Holes

A Holes must be bored so that the edge of the hole is at least 1¼ in. (32 mm) from the edges of the wood member »*300.4(A)(1)*«.

B The 1¼-in. (32-mm) setback applies to all locations (concealed and exposed).

C The 1¼-in. (32-mm) setback applies to studs, joists, rafters, etc.



Note

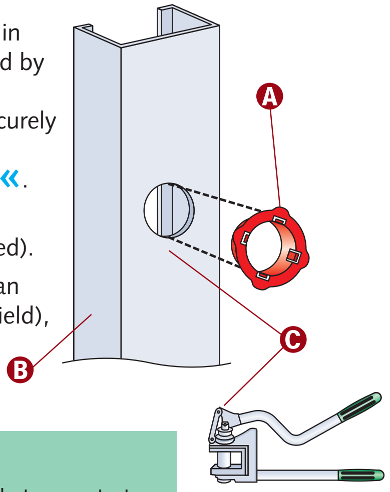
The largest hole that can be bored in a 3½-in. wood stud without using a steel plate (clip or sleeve) is 1 in. (provided the drill bit cuts straight through the center of the stud). The 1¼-in. (32-mm) setback must be maintained from both edges (front and back); 3½ in. minus 2½ in. (1¼-setback, two edges) leaves a remainder of 1 in.

Metal Framing Members

A Nonmetallic-sheathed cable passing through holes (or slots) in metal framing must be protected by listed bushings (or grommets) covering all metal edges and securely fastened in the opening prior to cable installation »*300.4(B)(1)*«.

B Section 300.4 applies to all locations (concealed and exposed).

C Openings (slots or holes) can be punched (either factory or field), cut, or drilled into the metal members »*300.4(B)(1)*«.



Note

Where nails (or screws) are likely to penetrate nonmetallic-sheathed cable (or electrical nonmetallic tubing), a steel plate (clip or sleeve) at least 1⁄16 in. (1.6 mm) thick shall be used to protect the cable or tubing »***300.4(B)(2)***«.

Steel Plates

A Where the bored hole is less than 1¼ in. (32 mm) from the edge, the cable (or raceway-type wiring method) shall be protected by a steel plate(s) or bushing(s) from penetration by screws or nails »*300.4(A)(1)*«.

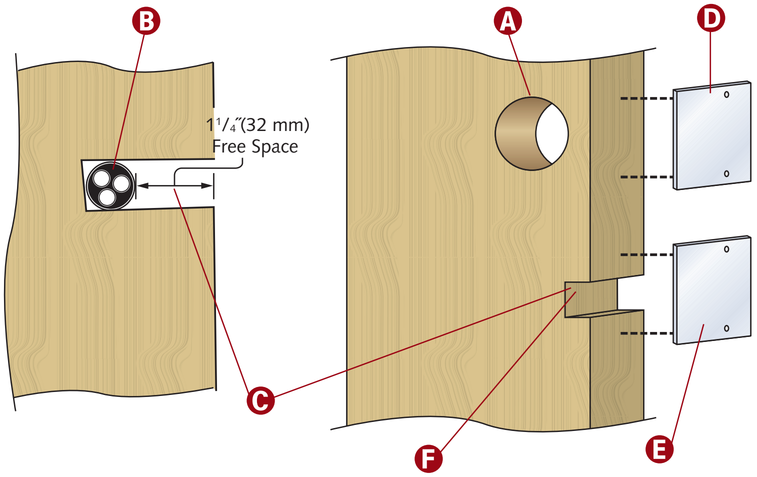
B Cables, installed in a groove, covered by wallboard, paneling, carpeting, etc., shall be protected by 1⁄16-in. (1.6-mm) thick steel plate, sleeve, or equivalent or by at least 1¼ in. (32 mm) free space for the full length of the groove in which the cable is installed »*300.4(F)*«.

C Where there is no potential of weakening building structure, cables (or raceways) can be laid within notches in wood studs, joists, rafters, etc. »*300.4(A)(2)*«.

D The steel plate(s) or bushing(s) must be at least 1⁄16 in. (1.6 mm) thick and of appropriate length and width to adequately cover the wiring »*300.4(A)(1)*«.

E The steel plate must be at least 1⁄16 in. (1.6 mm) thick and of appropriate length and width installed to cover the area of the wiring. The steel plate must be installed before the building finish is installed »*300.4(A)(2)*«.

F Requirements for notched wood members apply to all locations (concealed and exposed).



Note

A listed and marked steel plate that provides equal or better protection against nail or screw penetration shall be permitted, even if it is less than 1⁄16 in. (1.6 mm) thick »***300.4(A)(2) Exception No. 2***«.

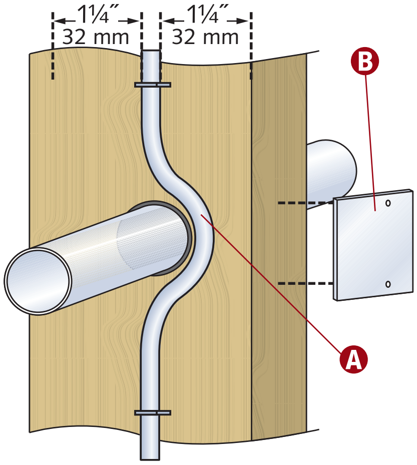
Parallel to Framing Members and Furring Strips

A Cables installed parallel to framing members (studs, joists, etc.) or installed parallel to furring strips shall be installed and supported so that the nearest outside surface of the cable is at least 1¼ in. (32 mm) from the nearest edge of the framing member or furring strip where nails (or screws) are likely to penetrate *»300.4(D)«*.

B If a 1¼-in. (32-mm) setback is not possible, the cable must be protected from penetration by nails (or screws) by a minimum 1/16-in. (1.6-mm) thick steel plate (sleeve, etc.) *»300.4(D)«*. A listed and marked steel plate less than 1/16 in. (1.6 mm) thick that provides equal or better protection against nail or screw penetration can be installed *»300.4(D) Exception No. 3«*.

Note

For concealed work in finished buildings or finished panels for prefabricated buildings, where such support is impracticable, cables can be fished between access points ***»300.4(D) Exception No. 2«***.

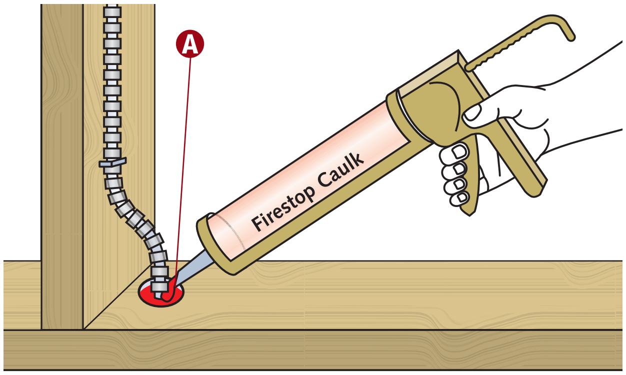


Maintaining the Integrity of Fire-Resistant-Rated Construction

A Electrical installation openings that penetrate into or through fire-resistant-rated structures (walls, partitions, floors, ceilings, etc.) must be firestopped using approved methods that maintain the fire-resistance rating *»300.21«*.

Caution

Some state and local jurisdictions may require that all penetrations (fire-rated and non-fire-rated) be sealed.



Note

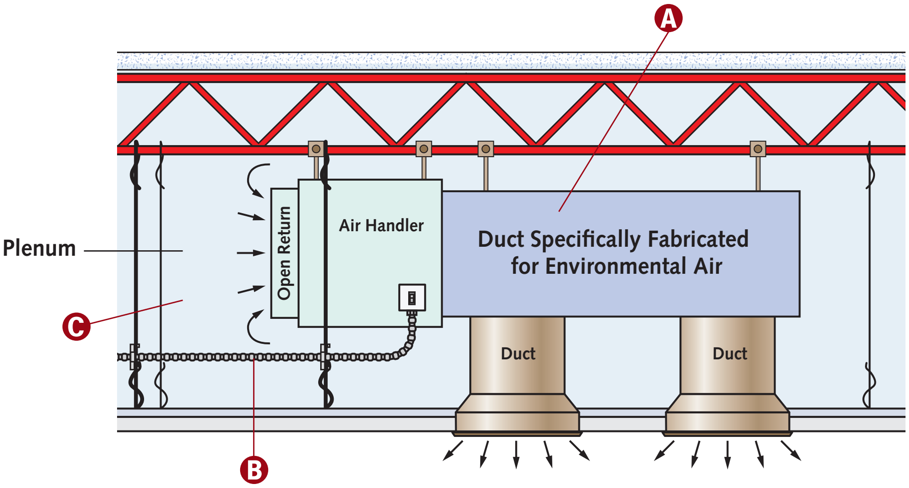
In hollow spaces, vertical shafts, and ventilation (or air-handling) ducts, electrical installations must not substantially increase the possible spread of fire or products of combustion ***»300.21«***.

Wiring in Ducts, Plenums, and Other Air-Handling Spaces

A Only wiring methods consisting of Type MI cable without an overall nonmetallic covering, Type MC cable employing a smooth or corrugated impervious metal sheath without an overall nonmetallic covering, electrical metallic tubing, flexible metallic tubing, intermediate metal conduit, or rigid metal conduit without an overall nonmetallic covering shall be installed in ducts specifically fabricated to transport environmental air. Flexible metal conduit shall be permitted, in lengths not to exceed 4 ft (1.2 m), to connect physically adjustable equipment and devices permitted to be in these fabricated ducts *»300.22(B)«*.

B Section 300.22(C) applies to spaces not specifically fabricated for environmental air-handling purposes but used for air-handling purposes as a plenum. This section shall not apply to habitable rooms or areas of buildings, the prime purpose of which is not air handling. Type MI cable without an overall nonmetallic covering, Type MC cable without an overall nonmetallic covering, Type AC cable, or other factory-assembled multiconductor cables (control or power) listed specifically for the use within an air-handling space, or listed prefabricated cable assemblies of metallic manufactured wiring systems without nonmetallic sheath shall be permitted to be installed in these spaces. All other types of cables and conductors must be installed in one of the raceways (or wireways) named in 300.22(C)(1).

C The space over a suspended ceiling used for environmental air-handling purposes is an example of the type of other space to which 300.22(C) applies *»300.22(C) Informational Note No. 1«*.



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Note

Wiring methods and cabling systems, listed for use in other spaces used for environmental air (plenums), shall be permitted to be installed in ducts specifically fabricated for environmental air-handling purposes under the following conditions: (1) the wiring methods or cabling systems shall be permitted only if necessary to connect to equipment or devices associated with the direct action upon or sensing of the contained air, and (2) the total length of such wiring methods or cabling systems shall not exceed 4 ft (1.2 m) ***»300.22(B) Exception«***.

Wiring in Ducts, Plenums, and Other Air-Handling Spaces *(continued)*

Caution

Ducts used to transport dust, loose stock, or flammable vapors shall not contain wiring systems of any type. No wiring system (of any type) shall be installed within a duct or shaft containing only such ducts used for vapor removal or for ventilation of commercial-type cooking equipment *»300.22(A)«*.

Note

Nonmetallic cable ties and other nonmetallic cable accessories used to secure and support cables shall be listed as having low smoke and heat release properties ***»300.22(C)(1)«***.

Note

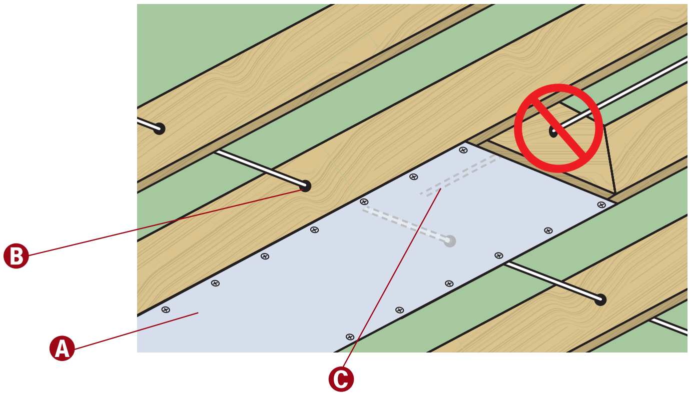
Metallic manufactured wiring systems (without nonmetallic sheath) having listed prefabricated cable assemblies are permitted in this type of installation ***»300.22(C)(1)«***.

Wiring within Air-Handling Spaces in Dwelling Units

Ⓐ Section 300.22 does not apply to **dwelling unit** joist or stud spaces where wiring passes perpendicular to the long dimension of such spaces *»300.22(C) Exception«*.

Ⓑ Conductors must remain at least 1¼ in. (32 mm) from the edges of wood members *»300.4(A)(1)«*.

Ⓒ Joist or stud spaces, used for environmental air-handling purposes, shall not contain nonmetallic-sheathed cable that runs along the long dimension *»300.22(C) Exception«*.



Securing Cables

Generally, all cables must be secured to the box, cabinet, etc. *»314.17(B)(2)«*.

Staples, cable ties, straps, etc. must be designed to secure cables and shall be installed so that cables are not damaged.

Ⓐ Type MC cable must be supported and secured at intervals not exceeding 6 ft (1.8 m) *»330.30(B)«*.

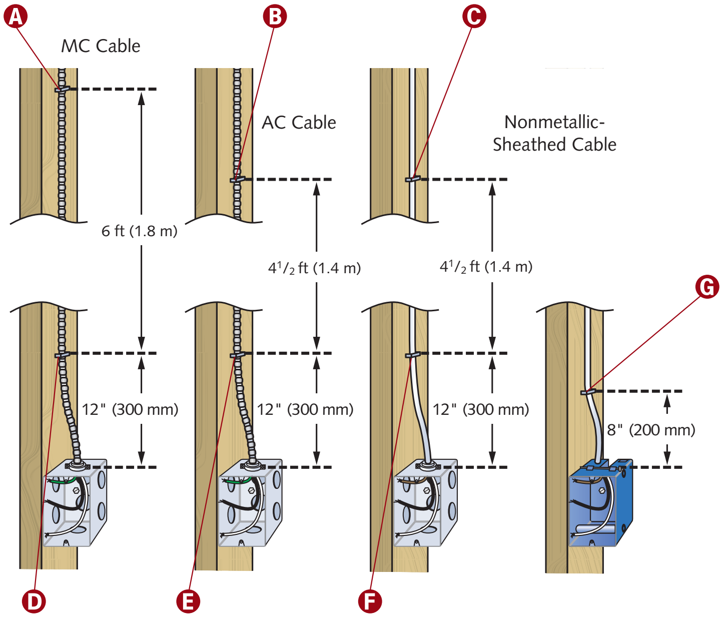
Ⓑ Type AC cable must be supported and secured at intervals not exceeding 4½ ft (1.4 m) *»320.30(B)«*.

Ⓒ Nonmetallic-sheathed cable must be supported and secured at intervals not exceeding 4½ ft (1.4 m) *»334.30«*.

Ⓓ Type MC cables containing no more than four conductors, size 10 AWG or smaller, must be secured within 12 in. (300 mm) of every box, cabinet, fitting, etc. *»330.30(B)«*.

Ⓔ Type AC cable must be secured within 12 in. (300 mm) of every box, cabinet, or fitting *»320.30(B)«*.

Ⓕ Nonmetallic-sheathed cable (secured to the box) must be secured within 12 in. (300 mm) of every box, cabinet, or fitting *»334.30«*.



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G Nonmetallic-sheathed cable *not* secured to a single-gang box must be secured within 8 in. (200 mm) »*314.17(B)(2) Exception*«.

Note

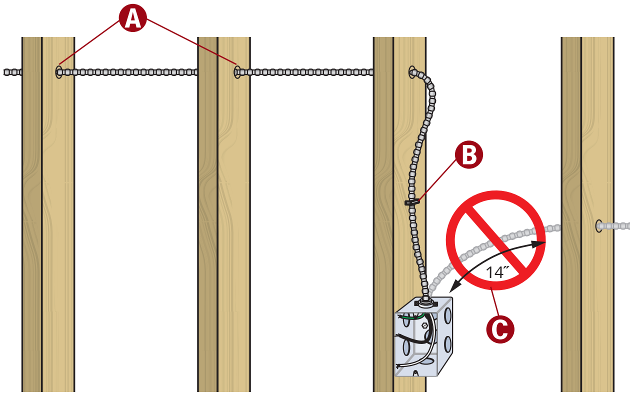
Cables fished between access points, where concealed in finished buildings (or structures) and where support is impracticable, can remain unsupported and unsecured ***»320.30(D)(1), 330.30(D)(1), and 334.30(B)(1)«***.

Cables Passing through Framing Members

A Cables running horizontally (or diagonally) are considered supported and secured when passing through a framing member (wood, metal, etc.), unless the support intervals exceed those listed for the specified cable. Cables installed in notches and protected by a 1⁄16-in. (1.6-mm) steel plate are also considered secured »*320.30(C), 330.30(C),* and *334.30(A)*«.

B Cables must be secured within 12 in. (300 mm) of every box, cabinet, fitting, etc.

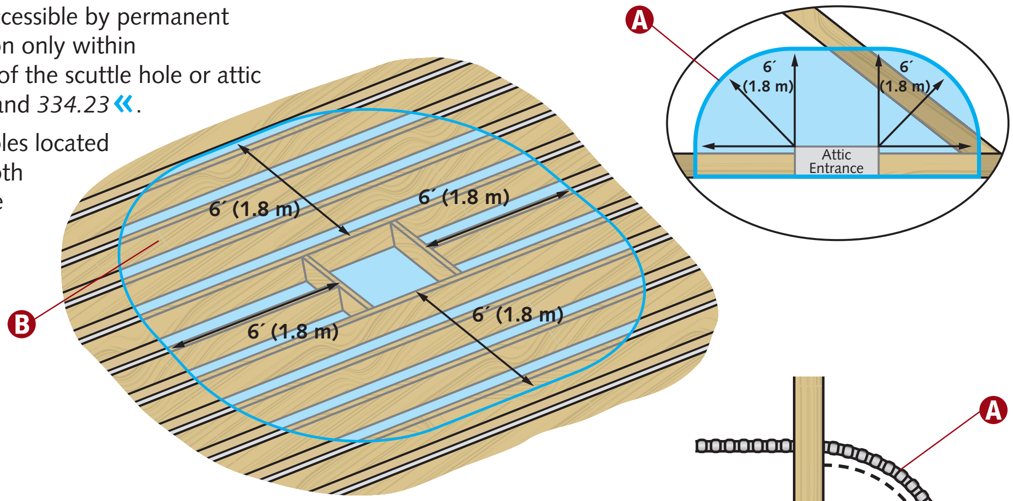
C This cable is not "secured." The support interval exceeds the maximum distance permitted.



Attics without Permanent Stairs or Ladders

A Attics and roof spaces not accessible by permanent stairs or ladders require protection only within 6 ft (1.8 m) of the nearest edge of the scuttle hole or attic entrance »*320.23(A), 330.23,* and *334.23*«.

B Protection is required for cables located within 6 ft (1.8 m) (measured both vertically and horizontally) of the attic entrance.



Bending Radius

Type AC cable must have a bending radius at least five times the diameter of the cable »*320.24*«.

Type MC cable (interlocked-type or corrugated sheath) has a minimum bending radius of seven times the external diameter of the metallic sheath »*330.24(B)*«.

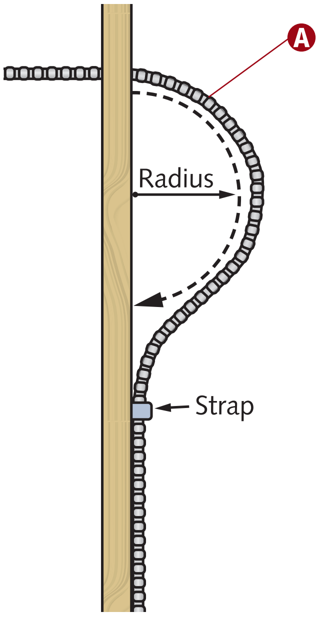
Nonmetallic-sheathed cable has a minimum bending radius of five times the cable diameter »*334.24*«.

A A curve radius is measured from the inner edge of the bend.

Example: If the outside diameter of Type MC cable (interlocked-type) is ½ (0.5) in. (13 mm), then the radius will need a measurement of 3½ in. (89 mm) (0.5 in. × 7 = 3.5 in.).

Caution

All bends shall be made so that the cable will not be damaged.



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Attics with Permanent Stairs or Ladders

Ⓐ Cables within 7 ft (2.1 m) of the floor (or floor joist) can run through the studs if meeting the requirements of 300.4(D). Cables more than 7 ft (2.1 m) above the floor (or floor joist) can run across the face of framing members.

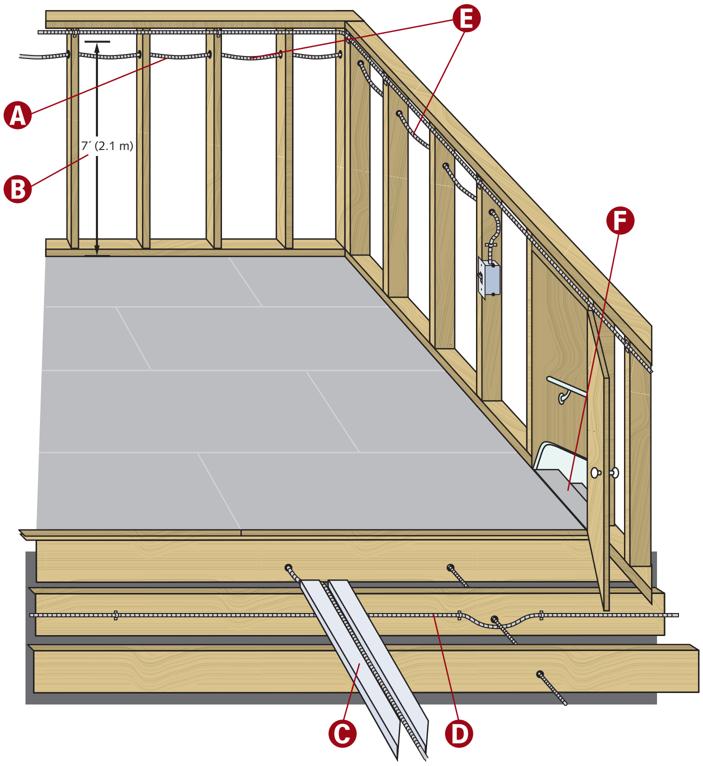
Ⓑ If cables are installed across the face of rafters or studding and they are located within 7 ft (2.1 m) of the floor (or floor joist) in attics or roof spaces that are accessible, the cable must be protected by guard strips that are at least as high as the cable »*320.23(A)*«.

Ⓒ Cables running across the top of floor joists must be protected by guard strips that are at least as high as the cable »*320.23(A)*«.

Ⓓ Cable installed parallel to the sides of rafters, studs, or floor joists does not require guard strips or running boards; however, the installation must also comply with 300.4(D) »*320.23(B)*«.

Ⓔ Cables not installed on the face (or surface) do not require guard strips or running boards.

Ⓕ Cables installed in attics (and roof spaces) accessible by permanent stairs (or ladders) must meet 320.23 provisions.



Note

Type MC cable and nonmetallic-sheathed cable must also comply with 320.23 ***»330.23 and 334.23«***.

Insulating (Antishort) Bushings

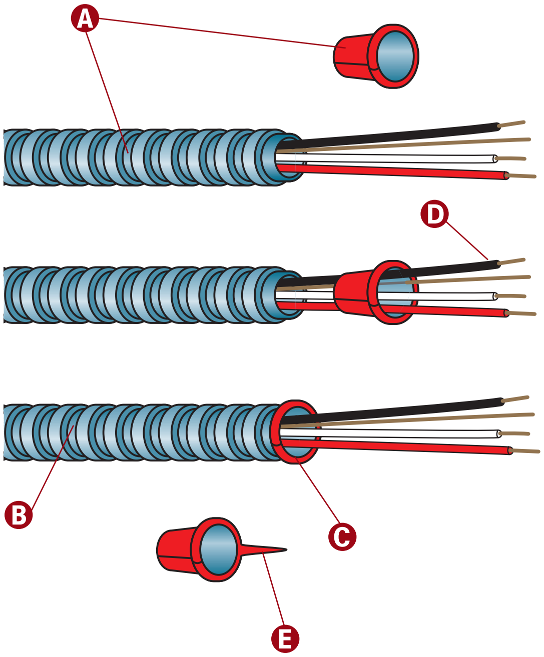
Ⓐ All armor termination points of AC cable shall have a fitting to protect the wires from abrasion, unless the outlet boxes (or fittings) are designed to afford equivalent protection. In addition, an insulating bushing (or its equivalent protection) shall be provided between the conductors and the armor »*320.40*«.

Ⓑ Type AC cable shall have a flexible metal tape armor »*320.100*«.

Ⓒ The connector or clamp that fastens Type AC cable to boxes or cabinets must be designed so that the insulating bushing (or its equivalent) is visible for inspections »*320.40*«.

Ⓓ Type AC cables shall have an internal bonding strip (copper or aluminum) in intimate contact with the armor for its entire length »*320.100*«.

Ⓔ Some insulating (antishort) bushings are manufactured so that part of the bushing extends past the connector or clamp (once installed), effectively acting as a flag. This flag increases the visibility of the bushing after installation.



Note

Insulating bushings in Type MC cable are optional rather than required. Although Article 330 does not require an insulating bushing between the conductors and the armor, it is a good practice to use one.

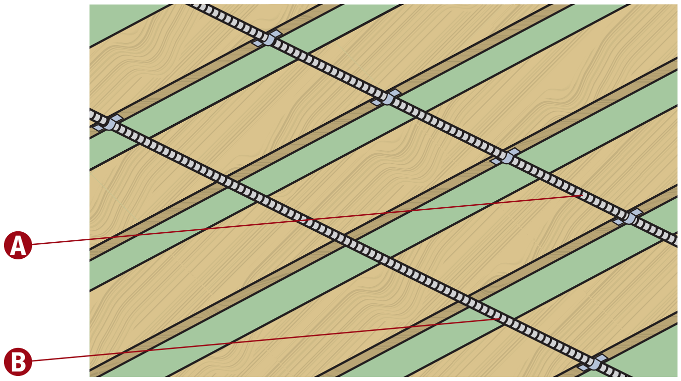
Note

Fittings used for connecting Type MC cable to boxes, cabinets, or other equipment shall be listed and identified for such use ***»330.6«***.

Exposed Runs of Type AC and MC Cables under Joists

A Exposed runs of Type AC cable installed on the underside of joists must be supported (and secured) at *every* joist and must be located so that physical damage is avoided »*320.15*«.

B Type MC cable must be supported (and secured) at intervals of 6 ft (1.8 m) or less »*330.30(B)* and *(C)*«.



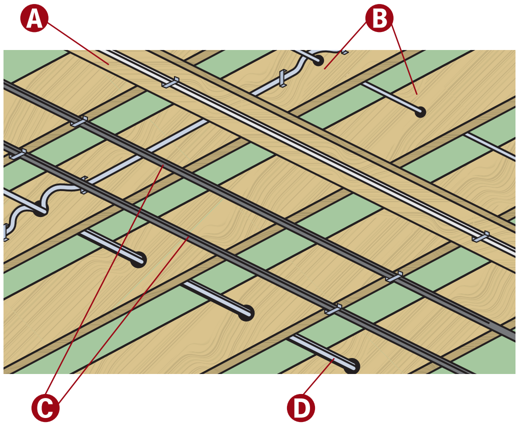
Exposed Nonmetallic-Sheathed Cable in Unfinished Basements and Crawl Spaces

A Exposed nonmetallic-sheathed cable (smaller than 8 AWG if three-conductor or 6 AWG if two-conductor) running at angles with joists in unfinished basements and crawl spaces must either be run through bored holes in the joists or on running boards »*334.15(C)*«.

B The nearest outside surface of installed and supported cable must be at least 1¼ in. (32 mm) from the edges of the framing member where nails or screws are likely to penetrate »*300.4(A)(1)*«.

C Three-conductor 8 AWG, or two-conductor 6 AWG, or larger, can be secured directly to the lower edges of the joists »*334.15(C)*«.

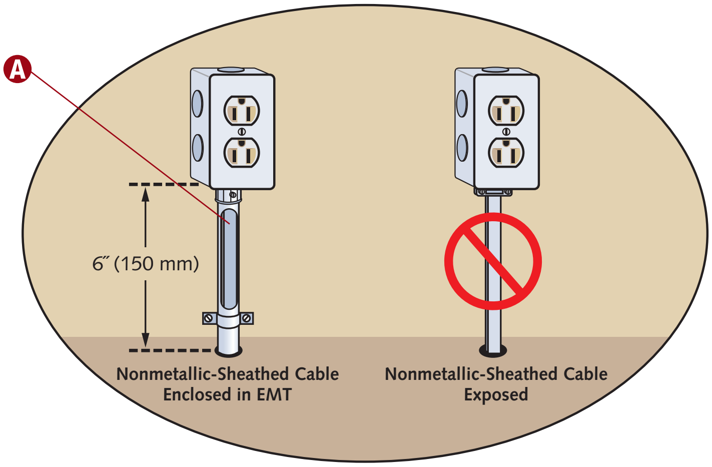
D Where current-carrying conductors in multiconductor cables are bundled or stacked longer than 24 in. (600 mm) without maintaining spacing, reduce the allowable ampacity of each conductor as shown in Table 310.15(C)(1) »*310.15(C)(1)*«.



Exposed Nonmetallic-Sheathed Cable Passing through a Floor

Cables entering or exiting conduit (or tubing) used for support or protection against physical damage require fittings on the conduit (or tubing) ends to prevent cable abrasion »*300.15(C)*«.

A Nonmetallic-sheathed cable passing through a floor must be enclosed in rigid (or intermediate) metal conduit, electrical metallic tubing, Schedule 80 PVC conduit, Type RTRC marked with the suffix -XW, or other approved means that extends at least 6 in. (150 mm) above the floor »*334.15(B)*«.


A
6″ (150 mm)
Nonmetallic-Sheathed Cable Enclosed in EMT
Nonmetallic-Sheathed Cable Exposed

Note

Raceway (or cable) openings in a fire-resistant-rated floor must be firestopped using approved methods to maintain the fire-resistance rating »***300.21***«.

If subject to physical damage, conductors, raceways, and cables must be protected »***300.4***«. Nonmetallic-sheathed cable can be protected by rigid (or intermediate) metal conduit, electrical metallic tubing, Schedule 80 PVC conduit, Type RTRC marked with the suffix -XW, or other approved means »***334.15(B)***«.

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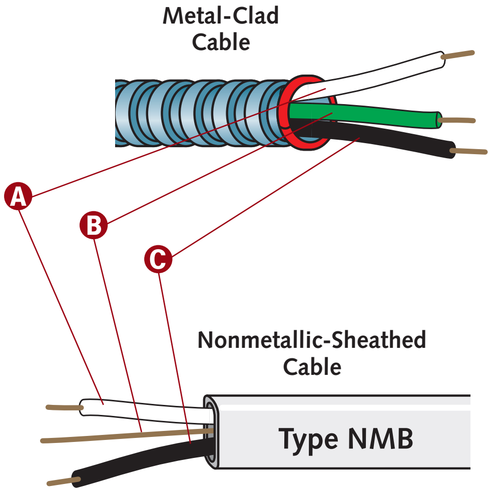
Conductor Identification

General Conductor Identification Provisions

A Generally, a conductor with a continuous white or gray covering shall be used only as a grounded-circuit conductor »*200.7*«.

B Equipment grounding conductors can be bare, covered, or insulated. Individually covered (or insulated) equipment grounding conductors must have a continuous outer finish that is either green or green with yellow stripe(s) »*250.119(A)*«.

C Conductors used as ungrounded (hot) conductors, whether single conductors or in multiconductor cables, must be finished in a way that clearly distinguishes them from grounded and equipment grounding conductors »*310.6(C)*«. Ungrounded (hot) conductors (except for a **high-leg** conductor) can be any color other than white, gray, green, or green with yellow stripe(s).



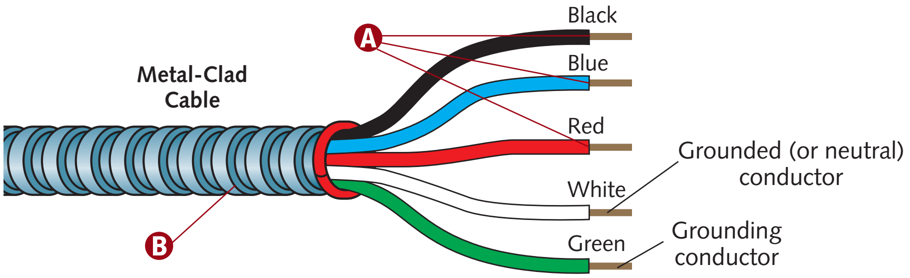
Note

Branch-circuit ungrounded conductors shall be identified in accordance with 210.5(C). Feeders shall be identified in accordance with 215.12(C) »***310.6(C)***«.

Three-Phase Conductor Identification

A Generally, ungrounded (hot) conductors can be any color except white, gray, green, or green with yellow stripe(s). A widely accepted practice is to identify 3-phase ungrounded (hot) conductors as black, red, and blue in 208/120-volt, 4-wire, wye-connected systems; and brown, orange, and yellow in 480/277-volt, 4-wire, wye-connected systems.

B Interlocking-armor Type MC cable requires an equipment grounding conductor.



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White Conductor Used as Ungrounded Switch Leg (Loop)

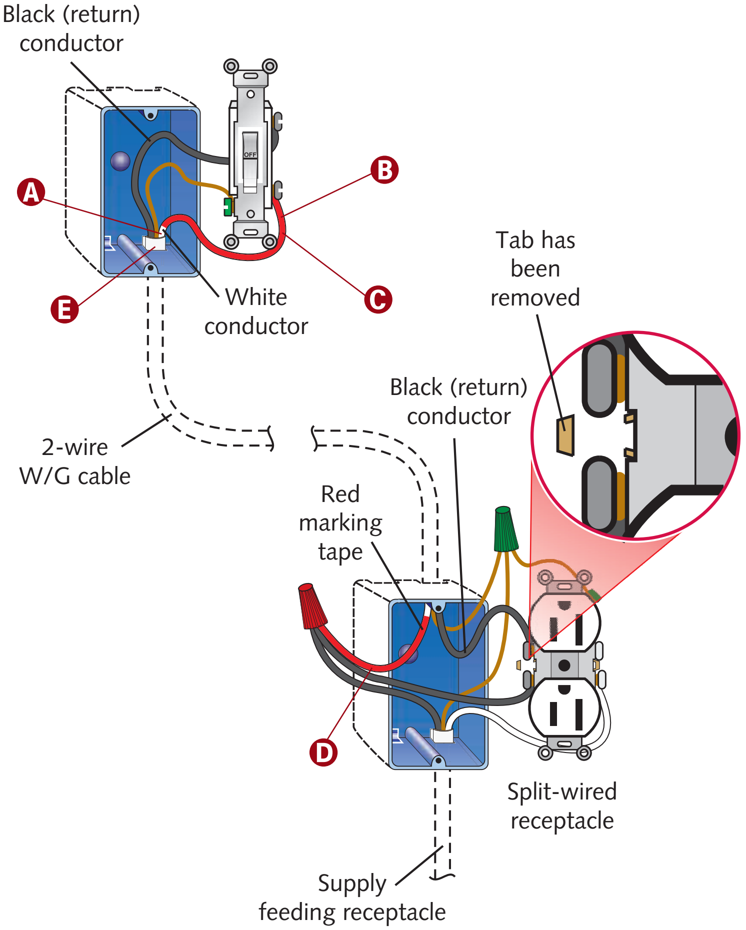
Ⓐ A cable assembly's white or gray conductor can be used as a switch loop (leg) in single-pole, three-way, and four-way switch installations, even though it is an ungrounded (hot) conductor »*200.7(C)(1)*«.

Ⓑ The white or gray conductor's new use as an ungrounded (hot) conductor must be permanently reidentified by marking tape, painting, or other effective means at its termination and at each location where the conductor is visible and accessible. Identification shall encircle the insulation and shall be a color other than white, gray, or green »*200.7(C)(1)*«.

Ⓒ Red marking tape has been wrapped around the white conductor, reidentifying it as an ungrounded (hot) conductor.

Ⓓ The white or gray conductor can be used to feed a switch or can be a traveler in three-way (or four-way) switch installations. The white or gray conductor shall not be used as a return conductor from the switch to the outlet »*200.7(C)(1)*«.

Ⓔ A grounded circuit conductor is not required at the switch location where the switch controls a receptacle load »*404.2(C)(4)*«.

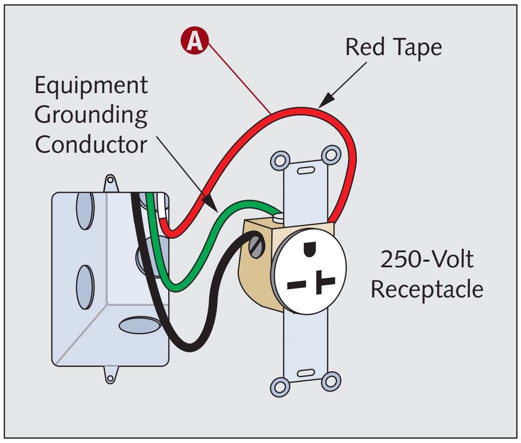


Caution

The grounded circuit conductor for the controlled lighting circuit shall be provided at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit for other than the locations stated in 404.2(C) »*404.2(C)*«.

White Conductor Used as an Ungrounded (Hot) Conductor

Ⓐ The white or gray conductor can be used as an ungrounded (hot) conductor if it is part of a cable assembly. The insulation must be permanently reidentified as an ungrounded conductor by marking tape, painting, or other effective means at its termination and at each location where the conductor is visible and accessible »*200.7(C)(1)*«.



Warning

Individual white or gray conductors in a conduit (or raceway) shall not be used (or reidentified) as an ungrounded conductor.

Note

Identification must encircle the insulation and shall be a color other than white, gray, or green »**200.7(C)(1)**«.

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Grounded Conductors

Grounded Conductors Provided at Switch Locations

A A grounded circuit conductor for the controlled lighting circuit is not required where multiple switch locations control the same lighting load such that the entire floor area of the room or space is visible from the single or combined switch locations; in this type of installation, the grounded circuit conductor shall only be required at one location »*404.2(C)*«.

B Switching in three-way and four-way configurations is done only in the ungrounded (hot) circuit conductor »*404.2(A)*«.

C In this installation, the supply is feeding one of the three-way switches. Therefore, the grounded circuit conductor is already in each switch location.

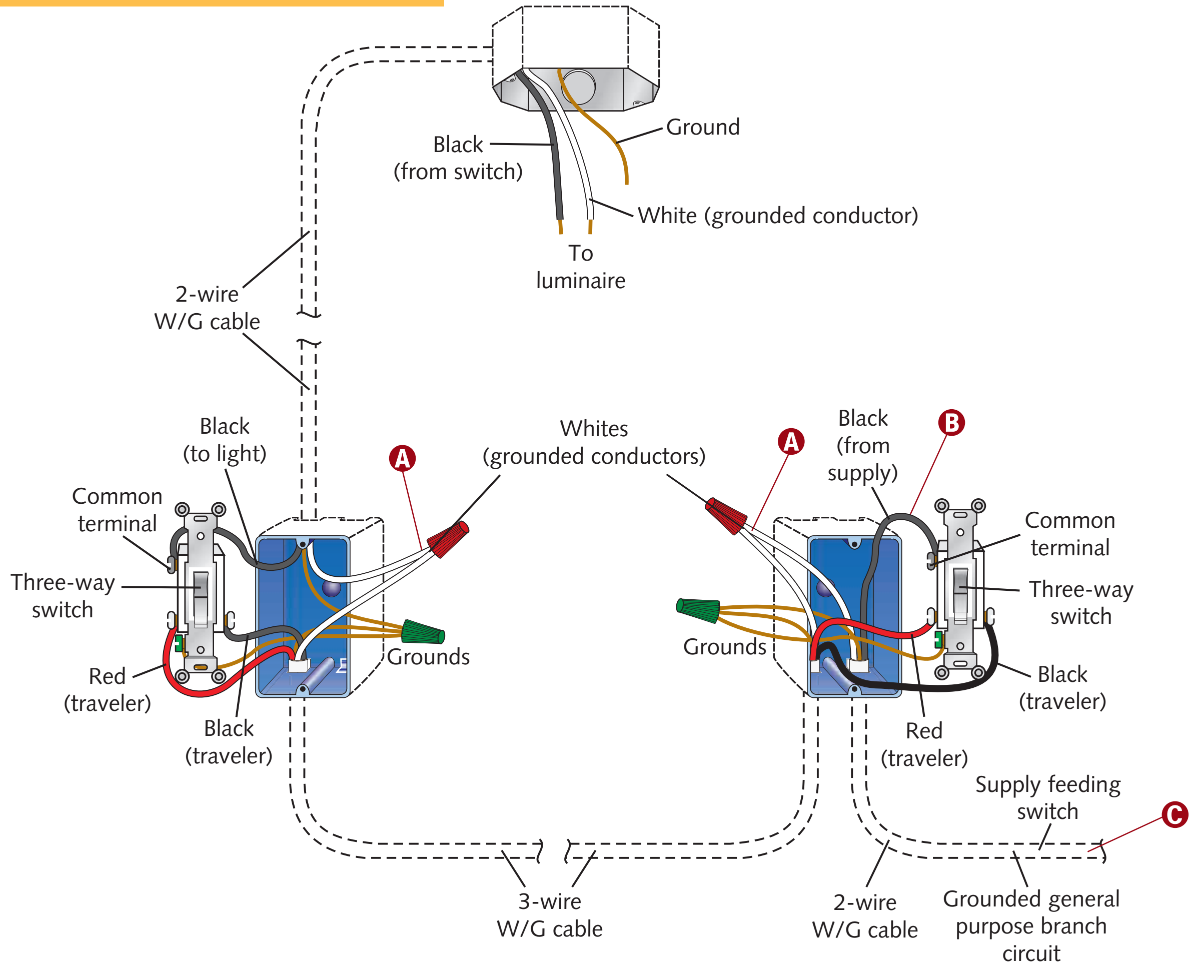
Warning

A grounding conductor (green, green with one or more yellow stripes, or bare) cannot be used (or reidentified) as an ungrounded (hot) or a grounded (white) conductor.

Note

The grounded circuit conductor for the controlled lighting circuit shall be installed at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit serving bathrooms, hallways, stairways, and habitable rooms or occupiable spaces as defined in the applicable building code. Where multiple switch locations control the same lighting load such that the entire floor area of the room or space is visible from the single or combined switch locations, the grounded circuit conductor shall only be required at one location. A grounded conductor shall not be required to be installed at lighting switch locations under any of the following conditions:

1. Where conductors enter the box enclosing the switch through a raceway, provided that the raceway is large enough for all contained conductors, including a grounded conductor.
2. Where snap switches with integral enclosures comply with 300.15(E).
3. Where lighting in the area is controlled by automatic means.
4. Where a switch controls a receptacle load »***404.2(C)***«.



Black
(from switch)
Ground
White (grounded conductor)
To
luminaire
2-wire
W/G cable
Black
(to light)
Common
terminal
Three-way
switch
Red
(traveler)
Black
(traveler)
A
Whites
(grounded conductors)
Grounds
A
Black
(from
supply)
B
Common
terminal
Three-way
switch
Grounds
Black
(traveler)
Red
(traveler)
Supply feeding
switch
C
3-wire
W/G cable
2-wire
W/G cable
Grounded general
purpose branch
circuit

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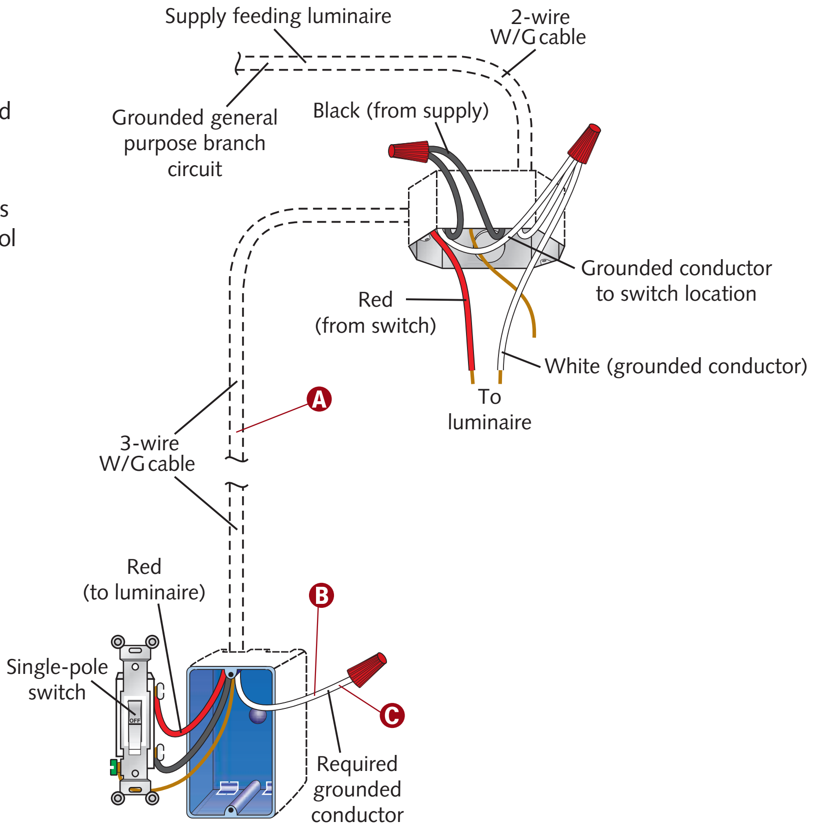
Grounded Conductor Provided for the Future

Ⓐ This cable installation does not meet any of the four exemptions in 404.2(C).

Ⓑ Although the grounded conductor will not be utilized in this current design, it must still be provided at the switch location unless meeting one of the exemptions in 404.2(C) »*404.2(C)*«.

Ⓒ The provision for a (future) grounded conductor is to complete a circuit path for electronic lighting control devices »*404.2(C) Informational Note*«.



Caution

The grounded conductor shall be extended to any switch location as necessary and shall be connected to switching devices that require line-to-neutral voltage to operate the electronics of the switch in the standby mode and shall meet the requirements of 404.22 »*404.2(C)*«. The connection requirement shall not apply to replacement or retrofit switches installed in locations prior to local adoption of 404.2(C) and where the grounded conductor cannot be extended without removing finish materials. The number of electronic control switches on a branch circuit shall not exceed five, and the number connected to any feeder on the load side of a system or main bonding jumper shall not exceed 25. For the purpose of this exception, a neutral busbar, in compliance with 200.2(B) and to which a main or system bonding jumper is connected shall not be limited as to the number of electronic lighting control switches connected »*404.2(C) Exception*«.

Underground Installations

Cover for Direct-Burial Cables and Conductors

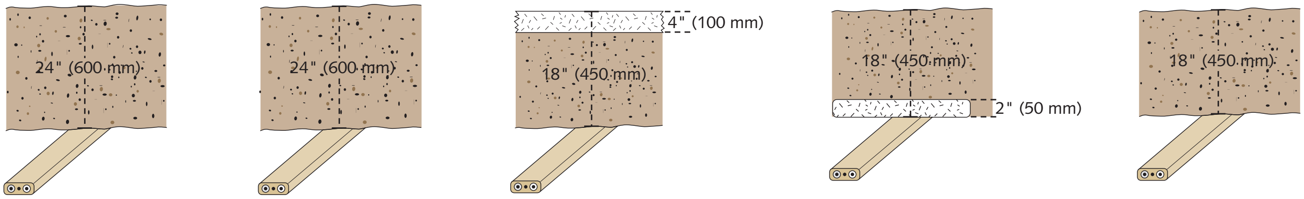
Cover measurement commences at the top surface of any direct-burial wiring method (conductor, cable, conduit, or other raceway) and ends at the closest point of the finished grade's top surface (including concrete, etc.) »*Table 300.5(A), Note 1*«.

Caution

Raceways must enclose underground cables and conductors installed under buildings unless the wiring method is Type MC or Type MI cable that is identified for direct burial »*300.5(C)* and *Table 300.5(A)*«.

Note

If the cover depth requirements of Table 300.5(A) cannot be met due to the presence of solid rock, the wiring must be installed in a raceway (metal or nonmetallic) approved for direct burial. The raceways must then be covered by a minimum of 2 in. (50 mm) of concrete that extends down to the solid rock surface »***Table 300.5(A), Note 5***«.



All locations **NOT** specified in Table 300.5(A)

Streets, highways, roads, alleys, driveways, and parking lots

Under minimum of 4-in. (100-mm) thick concrete exterior slab with no vehicular traffic (the slab must extend at least 6 in. [150 mm] beyond the underground installation)

In trench below 2-in. (50-mm) thick concrete or equivalent

One- and two-family dwelling driveways (and outdoor parking areas) used only for dwelling-related purposes **AND** airport runways, including adjacent areas where trespassing is prohibited

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Protection of Conductors and Cables

Underground cables and conductors installed under a building shall be in a raceway unless the wiring method is Type MC or Type MI cable that is identified for direct burial »*300.5(C)*«.

A Protection must extend at least 8 ft (2.5 m) above finished grade »*300.5(D)(1)*«.

B Direct-buried conductors and cables emerging from the ground must be protected by enclosures or raceways »*300.5(D)(1)*«.

C Conductors entering a building shall be protected to the point of entry »*300.5(D)(2)*«.

D Raceways and boxes shall be fastened in place securely »*300.11(A)*«.

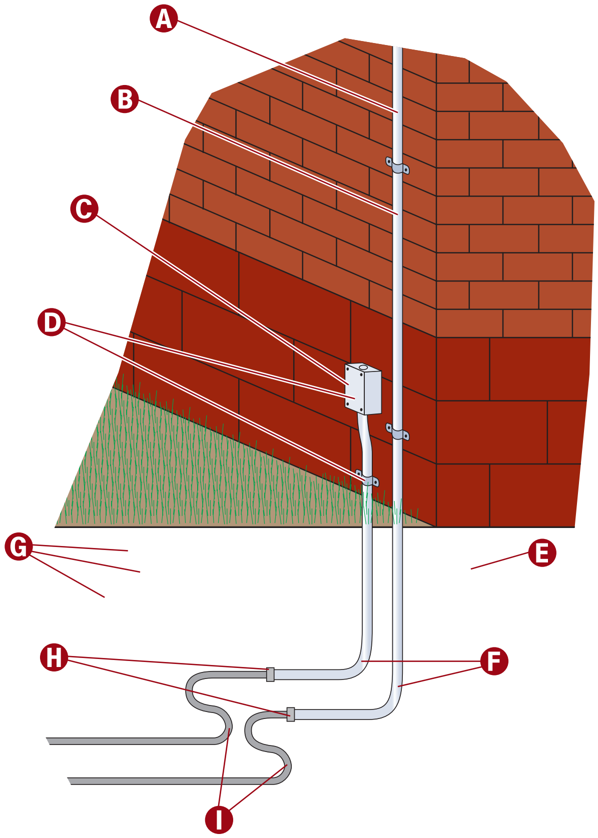
E Protection must extend below grade to a depth matching Table 300.5(A) cover requirements, up to a maximum depth of 18 in. (450 mm) »*300.5(D)(1)*«.

F Direct-buried conductors, raceways, or cables subject to movement by settlement (or frost) must be arranged to prevent damage to both the enclosed conductors and the equipment connected to the raceways »*300.5(J)*«.

G Excavation backfill shall not contain large rock, paving materials, cinders, large or sharp substances, or corrosive materials where damage to raceways, cables, or conductors may occur. Provide protection in the form of granular or selected material, suitable running boards, suitable sleeves, or other approved means to prevent physical damage to the raceway or cable »*300.5(F)*«.

H Where the conductors or cables emerge as a direct-burial wiring method, install a bushing or fitting to protect conductors from abrasion on the end of the conduit (or tubing) that terminates underground. A seal incorporating the same protective characteristics can be used in lieu of a bushing »*300.5(H)* and *300.15(C)*«.

I Section 300.5 recognizes "**S**" loops in underground direct burial cables and conductors to raceway transitions, expansion joints in raceway risers to fixed equipment, and the provision of flexible connections to equipment subject to settlement or frost heaves »*300.5(J) Informational Note*«.



Cables Permitted Underground

Cable Types	Article
IGS Integrated Gas-Spacer Cable	326
MV Medium Voltage Cable **A**	315
MI Mineral-Insulated Metal-Sheathed Cable	332
MC Metal-Clad Cable (where identified for such use)	330
USE Underground Service-Entrance Cable	338
UF Underground Feeder (and Branch-Circuit) Cable	340

Caution

Ensure the specific cable selected to be installed underground is the type identified for direct burial.

A Type MV conductors and cables used for direct burial applications shall be shielded, identified for such use, and installed in accordance with 305.15 »*315.36*«.

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Cover for Residential Branch Circuits

Residential branch circuits rated 120 volts (or less) with ground-fault circuit-interrupter (GFCI) protection and maximum overcurrent protection of 20 amperes ››*Table 300.5(A)*‹‹.

Caution

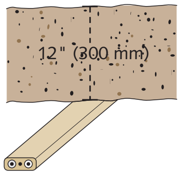
Raceways must enclose underground cables and conductors installed under buildings unless the wiring method is Type MC or Type MI cable that is identified for direct burial ››*300.5(C)*‹‹.

Note

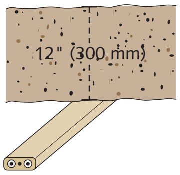
The minimum cover for residential branch circuits, in or under airport runways (including adjacent areas where trespassing is prohibited), is 18 in. (450 mm) ››***Table 300.5(A)***‹‹.

Lesser depths are permitted where cables and conductors rise for terminations (or splices) or where access is otherwise required ››***Table 300.5(A), Note 3***‹‹.

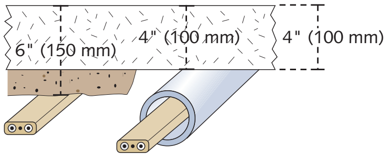
All locations **NOT** specified in Table 300.5(A)



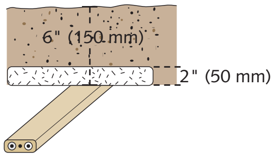
One- and two-family dwelling driveways (and outdoor parking areas) used only for dwelling-related purposes



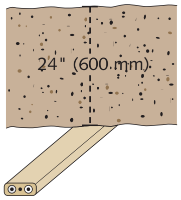
Under minimum of 4-in. (100-mm) thick concrete exterior slab with no vehicular traffic (the slab must extend at least 6 in. [150 mm] beyond the underground installation)



In trench below 2-in. (50-mm) thick concrete or equivalent



Streets, highways, roads, alleys, driveways, and parking lots



Cover for Low-Voltage Circuits

Circuits for control of irrigation and landscape lighting limited to not more than 30 volts and installed with Type UF or in other identified cable (or raceway) ››*Table 300.5(A)*‹‹.

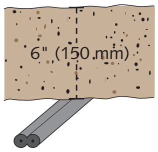
Note

A lesser depth shall be permitted where specified in the installation instructions of a listed low-voltage lighting system. A depth of 6 in. (150 mm) shall be permitted for pool, spa, and fountain lighting, installed in a nonmetallic raceway, limited to not more than 30 volts where part of a listed low-voltage lighting system ››***Footnotes a and b under Table 300.5(A)***‹‹.

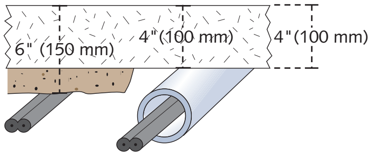
Note

Where a wiring method listed in Table 300.5(A), columns 1–3, is used for a circuit type in columns 4 and 5, the shallower depth of burial is allowed ››***Table 300.5(A), Note 4***‹‹.

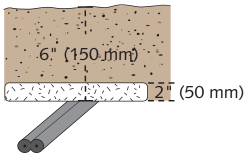
All locations **NOT** specified in Table 300.5(A)



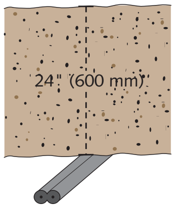
Under minimum of 4-in. (100-mm) thick concrete exterior slab with no vehicular traffic (the slab must extend at least 6 in. [150 mm] beyond the underground installation)



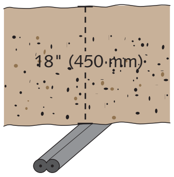
In trench below 2-in. (50-mm) thick concrete or equivalent



Streets, highways, roads, alleys, driveways, and parking lots



One- and two-family dwelling driveways (and outdoor parking areas) used only for dwelling-related purposes **AND** airport runways, including adjacent areas where trespassing is prohibited



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Special Application Cables

Flat Conductor Cable (for Installation Under Carpet Squares)

A Power feed, grounding connection, and shield system connection between the flat conductor cable (FCC) system and other wiring systems shall be accomplished in a transition assembly identified for this use »*324.40(D)*«.

B Carpet squares are required to cover floor-mounted Type FCC cable, cable connectors, and insulating ends. They shall not be larger than 39.37 in. × 39.37 in. (1.0 m × 1.0 m). Release-type adhesives must be used when adhering carpet squares to the floor »*324.41*«.

C All receptacles, receptacle housings, and self-contained devices used with the FCC system shall be identified for this use and shall be connected to the Type FCC cable as well as the metal shields. Connection from any equipment grounding conductor of the Type FCC cable to the shield system must be made at *each* receptacle »*324.42(A)*«.

D All FCC system components must be securely anchored to the floor (or wall) using an adhesive or mechanical system identified for this use. Floors must be prepared to ensure attachment of the FCC system to the floor until the carpet squares are placed »*324.30*«.

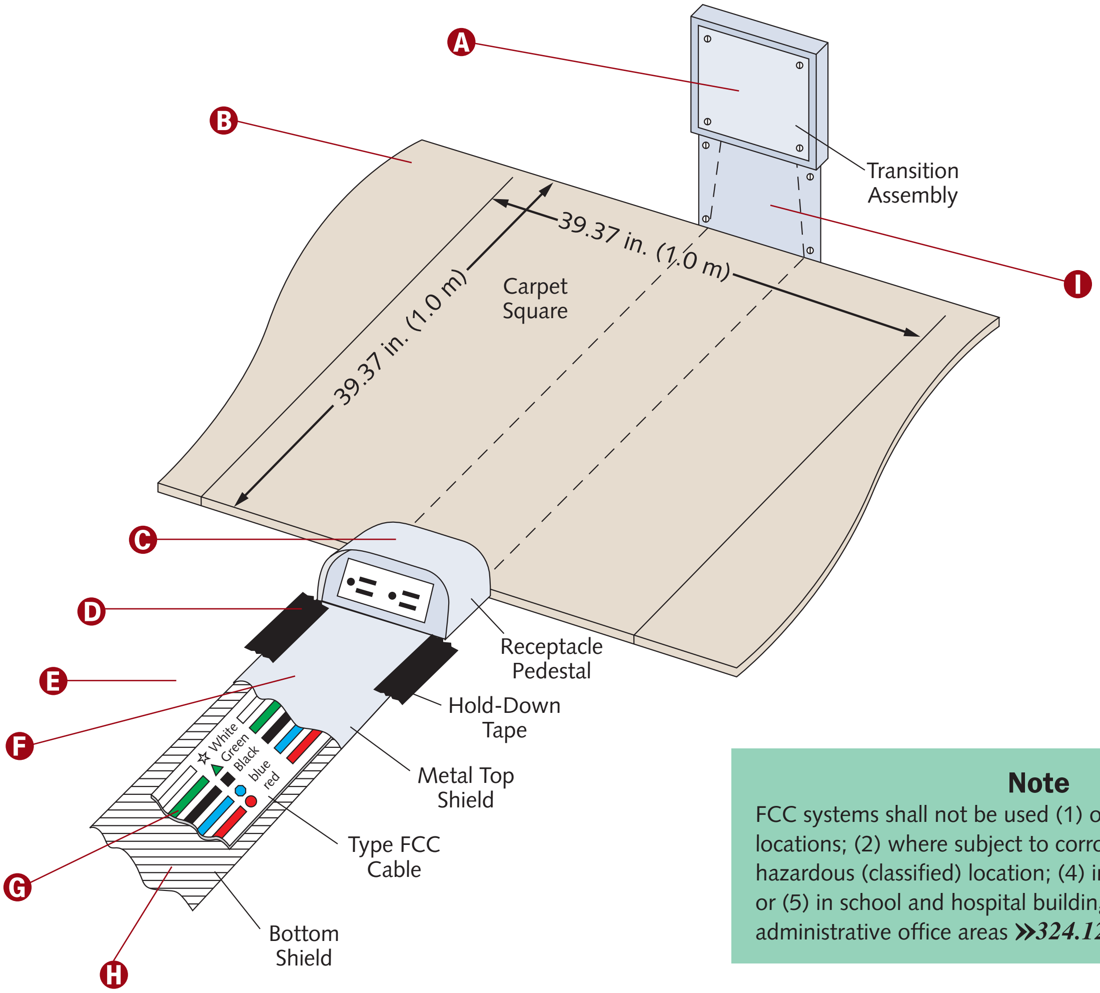
E Type FCC cable can be installed on hard, sound, smooth, continuous surfaces made of concrete, ceramic, composition flooring, wood, or similar materials »*324.10(C)*«.

F A metal top shield shall be installed over all floor-mounted Type FCC cable, connectors, and insulating ends. The top shield must completely cover all cable runs, corners, connectors, and ends »*324.40(C)(1)*«.

G Type FCC cable consists of three or more flat copper conductors placed horizontally edge to edge and enclosed within an insulating assembly »*Article 100*«. While the maximum current rating for general-purpose and appliance branch circuits is 20 amperes, individual branch circuits can have a current rating up to 30 amperes »*324.10(B)(2)*«.

H All Type FCC cable, connectors, and insulating ends require a bottom shield, either metallic or nonmetallic »*324.40(C)(2)* and *324.100(B)(1)*«.

I FCC systems are not permitted on wall surfaces unless enclosed in surface metal raceways »*324.10(D)*«.



Note

FCC systems shall not be used (1) outdoors or in wet locations; (2) where subject to corrosive vapors; (3) in any hazardous (classified) location; (4) in residential buildings; or (5) in school and hospital buildings, other than administrative office areas »***324.12***«.

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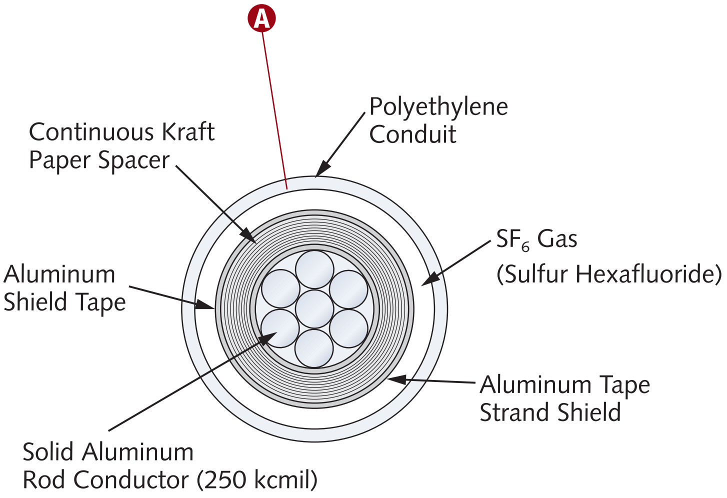
Integrated Gas-Spacer Cable (Type IGS)

The minimum bending radius is found in Table 326.24.

A run of Type IGS cable between pull boxes (or terminations) shall not contain more than the equivalent of four quarter bends (360 degrees total), including those bends located immediately adjacent to the pull box (or terminations) »*326.26*«.

Terminations and splices must be identified as suitable for maintaining the gas pressure within the conduit. A valve and cap must be provided for each length of the cable and conduit for monitoring and maintenance of gas pressure in the conduit »*326.40*«.


A
Polyethylene Conduit
Continuous Kraft Paper Spacer
SF_6 Gas (Sulfur Hexafluoride)
Aluminum Shield Tape
Aluminum Tape Strand Shield
Solid Aluminum Rod Conductor (250 kcmil)

Each conductor contains ½-in. (12.7-mm) diameter solid aluminum rod(s). A conductor assembly contains from one to nineteen of these rods, which are laid parallel. Conductor size ranges from a 250-kcmil minimum to a 4750-kcmil maximum »*326.104*«.

Ⓐ Type IGS cable is a manufactured assembly of conductor(s), each individually insulated and enclosed in a loose-fit nonmetallic flexible conduit as an integrated gas-spacer cable rated 0 to 600 volts »*Article 100*«.

Note

Type IGS cable shall not be (1) used as interior wiring, (2) exposed in contact with buildings, or (3) used above ground »*326.10* **and** *12*«.

Note

Table 326.80 provides the maximum ampacity for Type IGS cable.

Medium-Voltage Cable (Type MV)

Ⓐ Type MV is a solid dielectric insulated cable (single or multiconductor) rated 2001 volts up to and including 35,000 volts »*Article 100*«.

Ⓑ Type MV cable shall not be used where exposed to direct sunlight, unless identified for the use »*315.32(A)(8)*«.

Ⓒ Type MV cables must have copper, aluminum, or copper-clad aluminum conductors unless otherwise specified »*315.12(B)*«.

Ⓓ Conductor ampacity is found in Table 315.60(C)(1) through Table 315.60(C)(20), unless the cable is installed in a cable tray, in which case the ampacity shall be determined in accordance with 392.80(B) »*315.60(A)(1)*«.

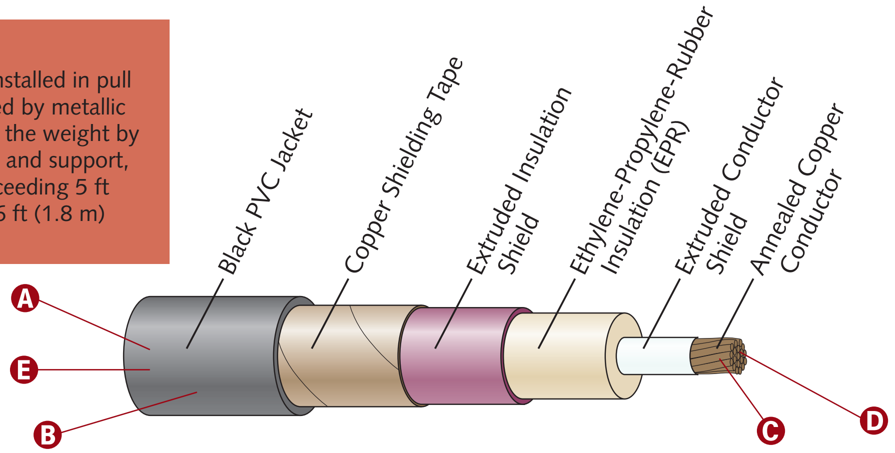
Ⓔ Conductor application and insulation shall comply with Table 315.10(A). Thickness of insulation and jacket for nonshielded conductors rated 2001 to 5000 volts shall comply with Table 315.10(B). Thickness of insulation for shielded conductors rated 2001 to 35,000 volts shall comply with Table 315.10(C) and 315.10(C)(1) through (C)(3) »*315.10*«.

Caution

Type MV cable terminated in equipment or installed in pull boxes or vaults shall be secured and supported by metallic or nonmetallic supports suitable to withstand the weight by cable ties listed and identified for securement and support, or other approved means, at intervals not exceeding 5 ft (1.5 m) from terminations or a maximum of 6 ft (1.8 m) between supports »*315.40*«.

Warning

Type MV cable shall be installed, terminated, and tested by qualified persons »*315.30*«.


Black PVC Jacket
Copper Shielding Tape
Extruded Insulation Shield
Ethylene-Propylene-Rubber Insulation (EPR)
Extruded Conductor Shield
Annealed Copper Conductor
A
E
B
C
D

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Mineral-Insulated Metal-Sheathed Cable (Type MI)

Type MI cable must be securely supported at intervals no greater than 6 ft (1.8 m) except where fished »*332.30*«.

A Type MI (mineral-insulated metal-sheathed) cable is a manufactured assembly of conductor(s) insulated with a highly compressed refractory mineral insulation and enclosed in a liquidtight (and gastight) continuous copper (or alloy steel) sheath »*Article 100*«.

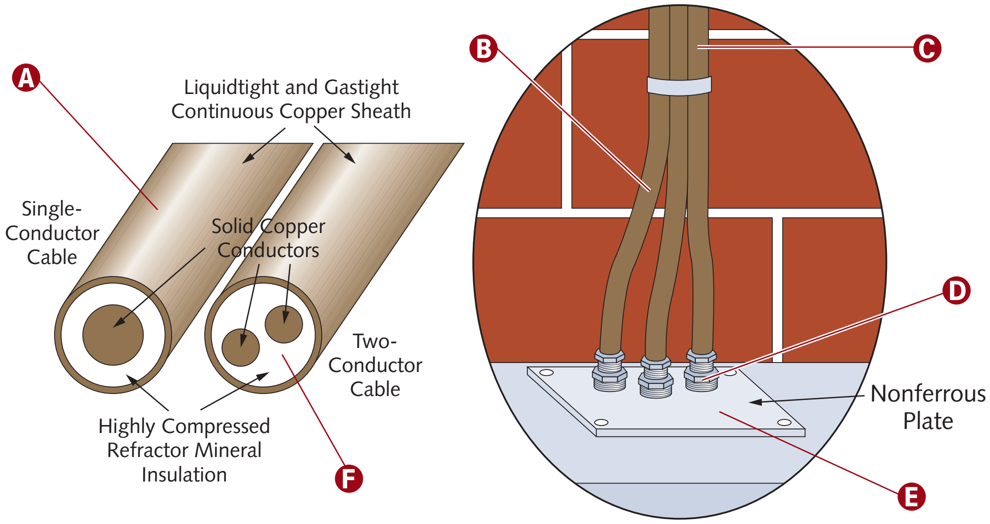
B The cable must not be damaged when bent. The radius of the inner edge of any bend shall not be less than five times the external diameter of the metallic sheath for cable that is not more than ¾ in. (19 mm) in external diameter. Cable diameters greater than ¾ in. (19 mm) but not more than 1 in. (25 mm) in external diameter must have a bend radius not less than ten times the external diameter »*332.24*«.

C When using single-conductor cables, all phase conductors and the neutral conductor (if any) must be grouped together to minimize induced voltages on the sheath »*332.31* and *300.20(A)*«.

D Only fittings identified for this use can connect Type MI cable to boxes, cabinets, or other equipment »*332.40(A)*«.

E If these single-conductor cables had entered a ferrous enclosure, compliance with 300.20(B) would be required to prevent heating from induction.

F Where Type MI cable terminates, a seal shall be provided *immediately* after stripping to prevent the entrance of moisture into the insulation. Each conductor extending beyond the sheath must be provided with an insulating material »*332.40(B)*«.



Summary

- When installed, cables must be protected from the possibility of physical damage.
- Conductors must be installed at least 1¼ in. (32 mm) from the edges of framing members, unless a steel plate (at least 1⁄16 in. [1.6 mm] thick) has been installed to protect the conductor(s).
- Conductors passing through metal studs (or framing members) may require protection in the form of bushings or steel plates.
- Fire-resistant-rated construction must remain intact once the electrical system has been installed.
- In dwellings, wiring can pass through the short dimension of a joist (or stud) space being used for environmental air-handling purposes.
- Cables must be secured within a certain distance from boxes (junction, device, etc.), unless the cable has been fished between access points.
- The maximum distance between supports depends on the type of cable.
- The minimum bending radius must be observed when installing a cable.
- Unless meeting one of the exemptions in 404.2(C), a grounded circuit conductor for the controlled lighting circuit shall be provided at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit.
- Certain sizes of nonmetallic-sheathed cable can be attached directly to the underside of exposed joists in unfinished basements.
- A cable assembly's white or gray conductor can be used as a switch loop (leg) in single-pole, three-way, and four-way switch installations after it has been reidentified.
- Table 300.5(A) contains minimum cover requirements for direct-buried cables and conductors.
- Chapter 3 of the *NEC* contains provisions for certain specialized cables.

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Unit 4 Competency Test

***NEC*® Reference** **Answer**

____________ ____________ 1. Nonmetallic-sheathed cable must be secured within ____________ in. from a two-gang plastic device box mounted in a wall.

____________ ____________ 2. Floor-mounted Type FCC cable, cable connectors, and insulating ends shall be covered with carpet squares no larger than ____________ in. square.

____________ ____________ 3. Type AC cable shall be supported and secured by staples; cable ties listed, and identified for securement and support; straps, hangers, or similar fittings; or other approved means at intervals not exceeding ____________ ft.

____________ ____________ 4. The minimum bending radius for integrated gas-spacer cable with an integral trade size 3-in. conduit is ____________ in.

____________ ____________ 5. ____________ is a factory assembly of one or more insulated circuit conductors with or without optical-fiber members enclosed in an armor of interlocking metal tape or a smooth or corrugated metallic sheath.

____________ ____________ 6. Where Type MI cable terminates, a seal shall be provided immediately after stripping to prevent the entrance of ____________ into the insulation.

____________ ____________ 7. Where nonmetallic-sheathed cable is run at angles with joists in unfinished basements, it shall be permissible to secure cables not smaller than three ____________ AWG conductors directly to the lower edges of the joists.

a) 12 b) 10 c) 8 d) 6

____________ ____________ 8. ____________ is a single or multiconductor solid dielectric insulated cable rated 2001 volts up to and including 35,000 volts, nominal.

____________ ____________ 9. The overall covering of Type UF cable shall be ____________.

I. flame retardant
II. suitable for direct burial in the earth
III. moisture-, fungus-, and corrosion-resistant

a) II only b) I and II only c) II and III only d) I, II, and III

____________ ____________ 10. Power feed, grounding connection, and shield system connection between the FCC system and other wiring systems shall be accomplished in a(n) ____________ identified for this use.

____________ ____________ 11. Type AC cable shall be permitted to be unsupported where the cable is not more than ____________ in. in length at terminals where flexibility is necessary.

a) 2 b) 6 c) 24 d) 72

____________ ____________ 12. The ____________ for the controlled lighting circuit shall be installed at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit serving bathrooms, hallways, stairways, and habitable rooms or occupiable spaces as defined in the applicable building code.

____________ ____________ 13. The minimum bending radius for metal-clad (corrugated sheath) cable is ____________ times the external diameter of the metallic sheath.

____________ ____________ 14. In both exposed and concealed locations, where a cable or raceway-type wiring method is installed through bored holes in joists, rafters, or wood members, holes shall be bored so that the edge of the hole is not less than ____________ in. from the edges of the wood member.

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NEC® Reference **Answer**

____________ ____________ 15. Where run across the top of floor joists or within ____________ ft of the floor or floor joists across the face of rafters or studding, in an attic that has permanent stairs, nonmetallic-sheathed cable must be protected by substantial guard strips that are at least as high as the cable.

____________ ____________ 16. Type FCC cable shall be clearly and durably marked on both sides at intervals of not more than 24 in. with the information required by 310.8(A) and with what additional information?

I. Material of conductors and ampacity

II. Rated frequency and number of phases

III. Maximum temperature rating

a) I only b) I and II only c) I and III only d) I, II, and III

____________ ____________ 17. ____________ is a factory assembly of one or more conductors insulated with a highly compressed refractory mineral insulation and enclosed in a liquidtight and gastight continuous copper or alloy steel sheath.

____________ ____________ 18. Armored cable installed in thermal insulation shall have conductors rated at ____________. The ampacity of the cable installed in these applications shall not exceed that of a 60°C-rated conductor.

a) 60°C b) 75°C c) 90°C d) 90°F

____________ ____________ 19. Type MC cable must be supported (and secured) at intervals not exceeding ____________ in.

a) 4½ b) 6 c) 54 d) 72

____________ ____________ 20. The maximum ampacity of a 500-kcmil, integrated gas-spacer cable (Type IGS) is ____________ amperes.

____________ ____________ 21. Type UF cable, buried under a driveway for a single-family dwelling unit, fed from a 15-ampere, GFCI-protected circuit must have a minimum cover of ____________ in.

a) 6 b) 12 c) 18 d) 24

____________ ____________ 22. In both exposed and concealed locations where nonmetallic-sheathed cables pass through either factory- or field-punched, cut, or drilled slots or holes in metal members, the cable shall be protected by ____________ or ____________ covering all metal edges that are securely fastened in the opening prior to installation of the cable.

____________ ____________ 23. A nonmetallic-sheathed cable, passing through a bored hole less than 1¼ in. from the edge of a wood framing member, must be protected by a steel plate (or bushing) at least ____________ in. thick.

____________ ____________ 24. In FCC systems, general-purpose and appliance branch circuits have a maximum current rating of ____________ amperes, while individual branch circuits have a maximum current rating of ____________ amperes.

____________ ____________ 25. Type MI cable shall be supported securely at intervals not exceeding ____________ ft by straps, staples, hangers, or similar fittings designed and installed so as not to damage the cable.

____________ ____________ 26. Type UF cable, buried under a one-family dwelling driveway, must have a minimum cover of ____________ in.

____________ ____________ 27. The provision for a (future) grounded conductor at a switch location that controls lighting loads is to complete a ____________ for electronic lighting control devices.

***NEC*® Reference** **Answer**

____________ ____________ 28. A cable assembly can have the white insulated conductor permanently reidentified to indicate its use as an ungrounded conductor but the reidentified conductor cannot be ____________.

a) one of the traveler conductors

b) the supply conductor from the outlet to the switch

c) the return conductor from the switch to the outlet

d) any of these conductors

____________ ____________ 29. Electrical installations in hollow spaces, vertical shafts, and ventilation or air-handling ducts shall be made so that the possible spread of fire or products of combustion will not be ____________.

____________ ____________ 30. A(n) ____________ is a compartment or chamber to which one or more air ducts are connected and that forms part of the air distribution system.

Unit 5

Section One: Foundational Provisions

Raceways and Conductors

Objectives

After studying this unit, the student should be able to:

- name the maximum number of bends for raceways installed between pull points.
- summarize rigid and intermediate metal-conduit provisions.
- determine the type of raceway best suited for each installation.
- explain intermediate metal conduit (IMC), rigid metal conduit (RMC), and electrical metallic tubing (EMT) support requirements.
- recall the unique characteristics of the different types of rigid polyvinyl chloride (PVC) conduits.
- clarify rigid nonmetallic conduit and electrical nonmetallic tubing provisions, both general and specific.
- identify the different types of flexible conduit, and be able to locate each related article.
- list raceway types other than conduit and tubing.
- calculate the correct electrical trade-size conduit required for each project.
- recall conductor properties.
- summarize conductor temperature limitations.
- clarify provisions pertaining to conductors connected in parallel.
- explain ampacity correction factors, including continuous loads, and how to apply them.

Introduction

Raceways are the conduits, or similar housing, whose dual function is to facilitate the installation (or removal) of electrical conductors and to provide protection from mechanical damage. Article 100 defines raceway as an enclosed channel of metallic (or nonmetallic) materials designed expressly for holding wires, cables, or busbars, with additional functions as permitted in the *National Electrical Code*. The term **raceway** applies to more than just tubular conduit.

This unit contains regulations for raceway systems that are frequently used (such as electrical metallic tubing and wireways), as well as raceway systems that are rarely used (such as cellular concrete floor raceways). In addition to defining different raceways, other important information is covered, such as minimum and maximum size, installation provisions, fittings, and support requirements. Instructions are presented on how to perform raceway fill calculations, a prerequisite in determining the size of raceway needed for particular circuits. A brief explanation of conductors, including ampacity correction factors and conductor temperature limitations, can be found near the conclusion of this unit. Understanding this unit will make finding the best raceway system for a particular project much easier.

Most raceway articles have sections entitled "Uses Permitted" and "Uses Not Permitted" (*NEC*® Chapter 3). These sections give locations (some specific) where the raceway system can (or cannot) be installed. Because most of these provisions are clearly understandable, this book does not repeat much of this information. Although not addressed in this unit, another important area is underground raceway installation (300.5). Underground installations are covered in Unit 4, which explains minimum cover requirements for underground cables and conductors. Use Table 300.5(A) (Minimum Cover Requirements) to find the minimum burial depth for different types of raceways installed in a variety of locations.

General Provisions

Suspended (Drop) Ceilings

A Raceways can be supported by independent (additional) support wires, secured at both ends. Support wires and associated fittings must provide adequate support »*300.11(B)*«.

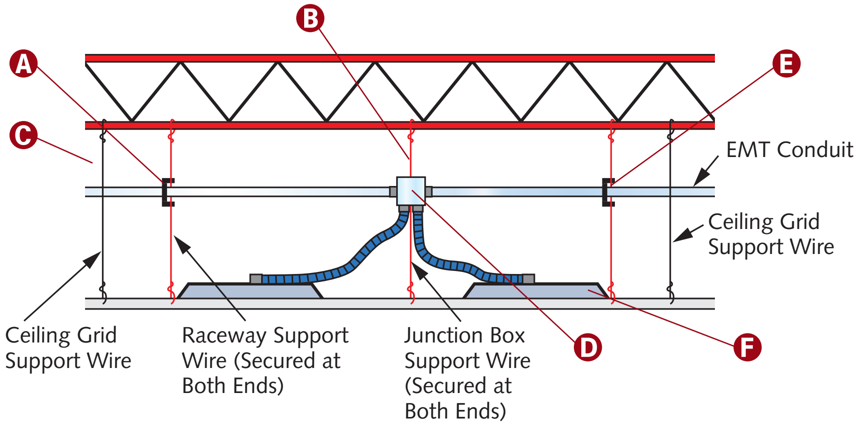
B Boxes can be secured by attaching independent (additional) support wires at both ends. Secure support must be provided by the support wires and associated fittings »*300.11(B)* and *314.23(D)(2)*«.

C Ceiling grid support wires shall not be used to support raceways.

D Certain boxes can also be mounted to suspended ceiling framing members »*314.23(D)*«.

E EMT conduit must be fastened securely within 3 ft (900 mm) of all boxes (outlet, junction, device, etc.) »*358.30(A)*«.

F Suspended ceiling system framing members used to support luminaires must be securely fastened to one another as well as to the building structure at appropriate intervals. Luminaires must be securely fastened to the ceiling framing member by mechanical means (bolts, screws, or rivets, etc.). Listed clips, identified for use with the type of ceiling framing member(s) and luminaire(s), are also permitted »*410.36(B)*«.



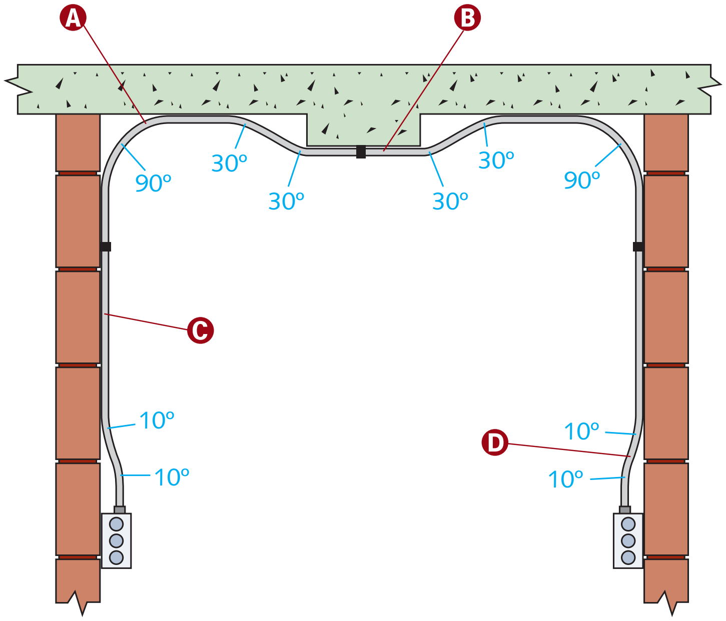
Maximum Bends in One Run

A The equivalent of four quarter bends (360° total) is the maximum allowed between pull points, for example, conduit bodies and boxes. Because the total bends in this conduit run is 340°, this installation falls within *NEC* specifications.

B The bend maximum of 360° applies to the following raceways: IGS (326.26), IMC (342.24(B)), RMC (344.24(B)), FMC (348.24(B)), LFMC (350.24(B)), PVC (352.24(B)), HDPE (353.24(B)), NUCC (354.24(B)), RTRC (355.24(B)), LFNC (356.24(B)), EMT (358.24(B)), and ENT (362.24(B)).

C Generally, raceway installation must be complete between outlet, junction, or splicing points prior to the installation of conductors »*300.18(A)*«.

D All bends are counted, even those located immediately adjacent to the pull box (or termination). A box offset with two 10° bends counts as 20°.



Note

Metal raceways must not be supported, terminated, or connected by welding unless specifically permitted by design or *Code* specifications »*300.18(B)*«.

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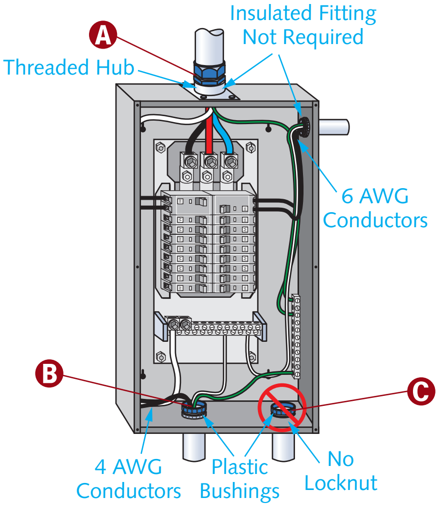
Insulated Fittings

Ⓐ An insulated fitting is not required if a smoothly rounded (or flared) entry for conductors is provided by threaded hubs (or bosses) that are an integral part of a cabinet, box enclosure, or raceway »*300.4(G)*«.

Ⓑ Where raceways containing 4 AWG or larger insulated circuit conductors enter a cabinet (box, enclosure, or raceway), the conductors must be protected by an identified fitting that provides a smoothly rounded insulating surface, unless the conductors are separated from the fitting (or raceway) by other securely attached identified insulating material »*300.4(G)*«.

Ⓒ Conduit bushings constructed completely of insulating material shall not be used to secure a fitting or raceway »*300.4(G)*«. An insulating (plastic, thermoplastic, etc.) bushing shall not replace a locknut. The insulated bushing must be installed prior to the installation of conductors.



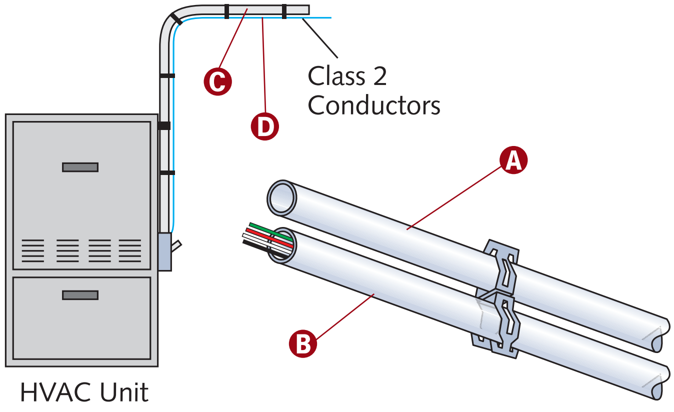
Raceways Supporting Raceways

Ⓐ Conduits (not used as raceways) may support raceways if fastened securely in place with approved fittings »*300.11(C)*«.

Ⓑ Raceways *shall not* be used to support other raceways, cables, conductors, or nonelectric equipment unless the raceway or means of support is identified as a means of support »*300.11(C)(1)*«.

Ⓒ This conduit contains power supply conductors for HVAC unit.

Ⓓ Raceways containing power supply conductors for electrically controlled equipment can support Class 2 circuit conductors (or cables) used solely for connection to the equipment control circuits »*300.11(C)(2)*«.



Conduit Thickness

Ⓐ Internal diameters for each electrical trade size conduit and tubing are listed in Table 4 of Chapter 9.

Ⓑ Ten 10 AWG THHN conductors are permitted in ¾-in. EMT.

Ⓒ Eleven 10 AWG THHN conductors are permitted in ¾-in. IMC.

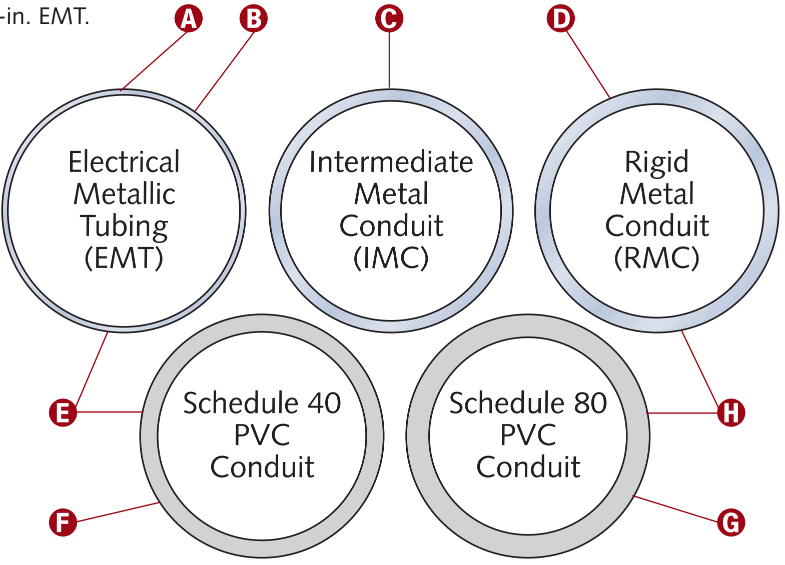
Ⓓ Ten 10 AWG THHN conductors are permitted in ¾-in. RMC.

Ⓔ Annex C (preceding the index in the back of the *Code* book) can be used to find the maximum number of conductors permitted in each electrical trade size conduit or tubing. The conductors must be the same size (total cross-sectional area including insulation) when using Annex C.

Ⓕ Nine 10 AWG THHN conductors are permitted in ¾-in. schedule 40 PVC.

Ⓖ Seven 10 AWG THHN conductors are permitted in ¾-in. schedule 80 PVC.

Ⓗ The internal diameters of different types of conduit vary. Therefore, a group of conductors that fit into one conduit may not fit into another type, even though it is the same electrical trade size.


Ⓐ
Ⓑ
Ⓒ
Ⓓ
Electrical Metallic Tubing (EMT)
Intermediate Metal Conduit (IMC)
Rigid Metal Conduit (RMC)
Ⓔ
Schedule 40 PVC Conduit
Schedule 80 PVC Conduit
Ⓗ
Ⓕ
Ⓖ

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Bending Radius

Ⓐ Bends must be made so that the conduit or tubing remains undamaged with its internal diameter basically undiminished. For any field bend, the radius of the curve to the centerline of the conduit must not be less than indicated in Table 2 of Chapter 9. Raceways permitted to use the "One Shot and Full Shoe Benders" column include IMC »*342.24(A)*«, RMC »*344.24(A)*«, and EMT »*358.24(A)*«.

Ⓑ The bending radius of certain other raceways must not be less than shown in the column titled "Other Bends." They include
FMC »*348.24(A)*«,
LFMC »*350.24(A)*«,
PVC »*352.24(A)*«,
LFNC »*356.24(A)*«, and
ENT »*362.24(A)*«.

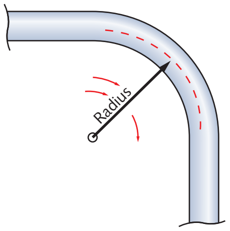


Table 2 (Chapter 9) Radius of Conduit and Tubing Bends

Conduit Size	One Shot and Full Shoe Benders	Other Bends
Trade Size	Bending Radius (in in.)	Bending Radius (in in.)
½	4	4
¾	4½	5
1	5¾	6
1¼	7¼	8
1½	8¼	10
2	9½	12
2½	10½	15
3	13	18
3½	15	21
4	16	24
5	24	30
6	30	36

Nonflexible Conduit (and Tubing)

Rigid Metal Conduit: Type RMC

Ⓐ Rigid metal conduit (RMC) is a threadable raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed with its integral or associated coupling and appropriate fittings »*Article 100*«.

Ⓑ RMC is the heaviest (thickest-walled) classification of metal conduit.

Ⓒ Threadless couplings and connectors used with conduit must be made tight. Those buried in masonry (or concrete) must be the concrete-tight type. If installed in wet locations, they must comply with 314.15 »*344.42(A)*«.

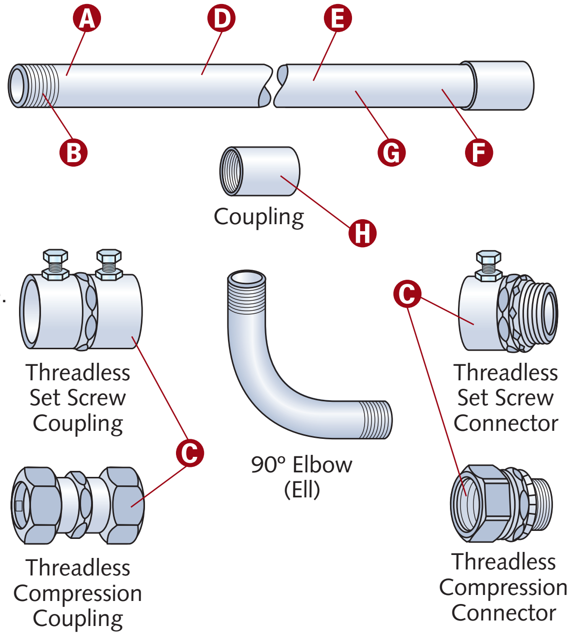
Ⓓ The minimum approved electrical trade size for RMC is ½ in. »*344.20(A)*«. The maximum approved electrical trade size for RMC is 6 in. »*344.20(B)*«.

Ⓔ RMC shall be permitted as an equipment grounding conductor »*344.60*«.

Ⓕ Galvanized steel and stainless steel RMC can be used under all atmospheric conditions, within all types of occupancies »*344.10(A)(1)*«.

Ⓖ Contact of dissimilar metals (except for the combination of aluminum and steel) should be avoided wherever possible to lessen the potential for galvanic action »*344.14*«.

Ⓗ RMC usually ships in standard lengths of 10 ft (3.05 m), including the coupling. Normally one coupling is furnished with each length.


A
D
E
B
G
F
Coupling
H
Threadless Set Screw Coupling
C
90° Elbow (Ell)
C
Threadless Set Screw Connector
Threadless Compression Coupling
Threadless Compression Connector

Note

RMC shall be made of one of the following: (1) steel with protective coatings; (2) aluminum; (3) red brass; or (4) stainless steel »**344.100**«.

Note

Galvanized steel, stainless steel, and red brass RMC, elbows, couplings, and fittings can be installed in concrete, in direct contact with the earth, in direct burial applications, or in areas subject to severe corrosive influences where protected by corrosion protection approved for the condition »**344.10(B)(1)**«.

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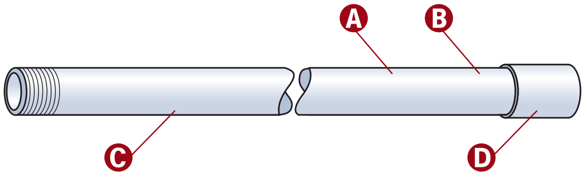
Intermediate Metal Conduit: Type IMC

A The minimum approved electrical trade size for IMC is ½ in. »*342.20(A)*«.

B The maximum approved electrical trade size for IMC is 6 in. »*342.20(B)*«.

C The definition for intermediate metal conduit (IMC) and rigid metal conduit (RMC) is essentially the same »*Article 100*«. However, as the name implies, IMC is lighter in weight and is constructed with thinner walls than RMC. Unlike RMC, IMC is only manufactured of steel that provides protective strength equivalent to thicker-walled conduits.

D IMC is a steel threadable raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when installed with its integral or associated coupling and appropriate fittings »*Article 100*«. IMC shall be permitted as an equipment grounding conductor »*342.60*«.



Note

For other similarities between IMC and RMC, read Articles 342 and 344.

Cutting, Reaming, and Threading

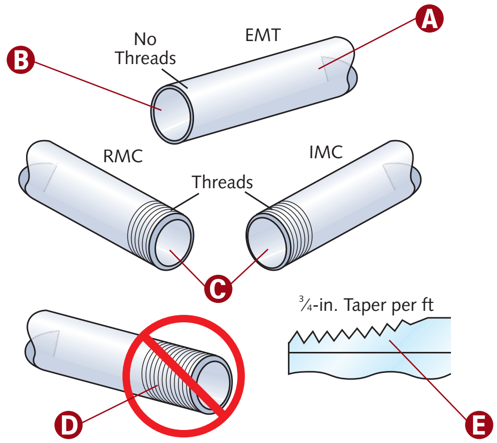
A Electrical metallic tubing must not be threaded. Factory threaded integral couplings can be used »*358.28(B)*«.

B All EMT cut ends must be reamed (or otherwise finished) to remove rough edges »*358.28(A)*«.

C All cut ends of IMC and RMC must be reamed (or otherwise finished) to remove rough edges »*342.28 and 344.28*«.

D Running threads shall not be used on conduit for coupling connections »*342.42(B)* and *344.42(B)*«.

E Threading conduit in the field requires a standard cutting die with a ¾-in. taper per ft (1 in 16) »*342.28* and *344.28*«.



RMC, IMC, and EMT Support Requirements

A The maximum support interval for RMC, IMC, and EMT is 10 ft (3 m) »*342.30(B)(1), 344.30(B)(1),* and *358.30(A)(1)*«.

B In addition, each conduit (or tube) must be securely fastened within 3 ft (900 mm) of each conduit termination (outlet box, junction box, device box, cabinet, conduit body, etc.) »*342.30(A)(1), 344.30(A)(1),* and *358.30(A)(2)*«.

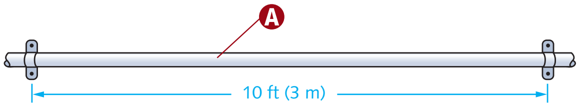
C If structural members are not available within 3 ft (900 mm), a distance of 5 ft (1.5 m) is acceptable for IMC and RMC »*342.30(A)(2)* and *344.30(A)(2)*«.

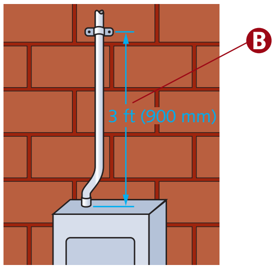
D Unbroken lengths of EMT, that is, without coupling, can be fastened within 5 ft (1.5 m) where structural members do not readily permit fastening within 3 ft (900 mm) »*358.30(A) Exception No. 1*«.

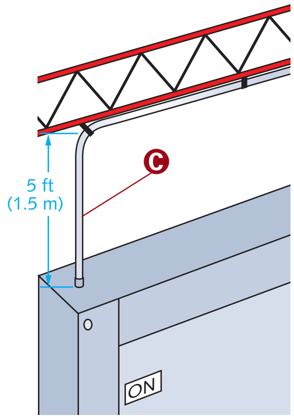
Note

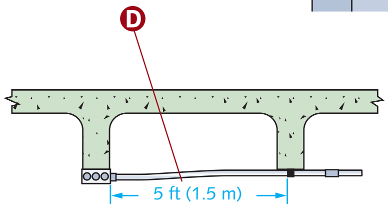
RMC, IMC, and EMT must be installed as a complete system before installing conductors
»**342.30, 344.30, and 358.30**«.

It is not required (where approved) that RMC and IMC be securely fastened within 3 ft (900 mm) of the service head for above-the-roof mast termination
»**342.30(A)(3) and 344.30(A)(3)**«.









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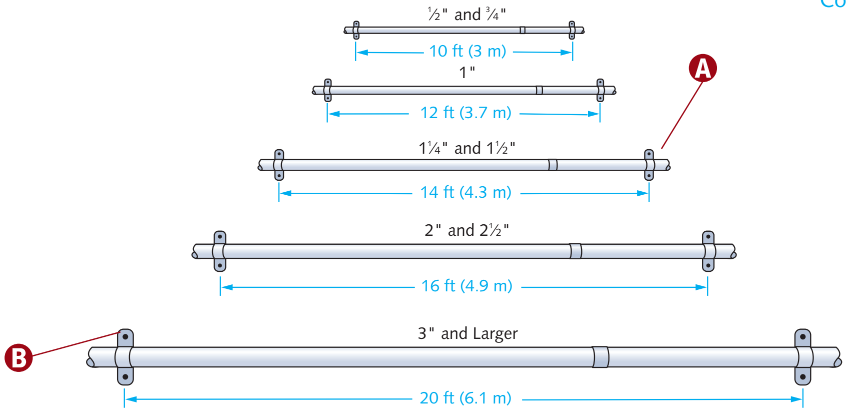
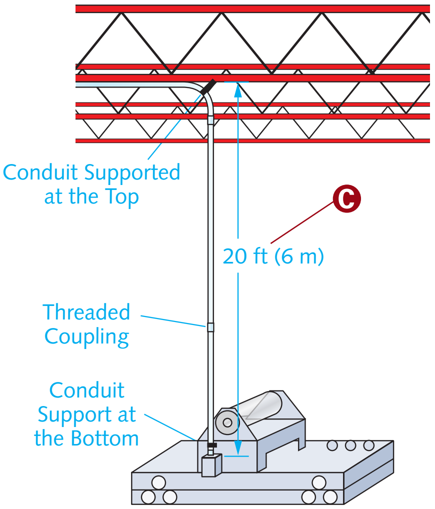
RMC and IMC with Threaded Couplings

A Straight runs of RMC and IMC made up with threaded couplings can be supported in accordance with Table 344.30(B), provided the conduit is made up with threaded couplings and supports that prevent transmission of stresses to termination where conduit is deflected between supports »*342.30(B)(2)* and *344.30(B)(2)*«.

B The maximum distance between supports increases as the conduit size increases.

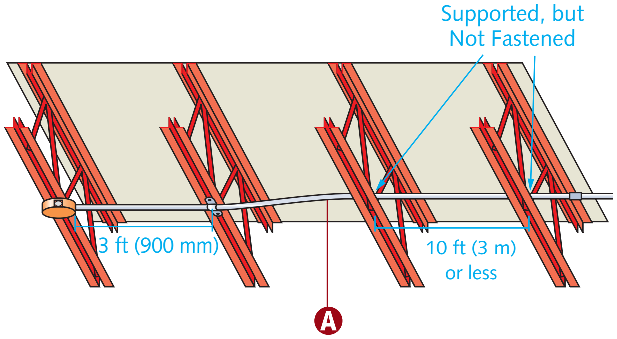
C The distance between supports can be increased to 20 ft (6 m) for exposed vertical risers from industrial machinery or fixed equipment, provided (1) the conduit is made up with threaded couplings; (2) the conduit is supported and securely fastened at the top and bottom of the riser; and (3) no other means of intermediate support is readily available »*342.30(B)(3)* and *344.30(B)(3)*«.


½" and ¾"
10 ft (3 m)
1"
12 ft (3.7 m)
A
1¼" and 1½"
14 ft (4.3 m)
2" and 2½"
16 ft (4.9 m)
B
3" and Larger
20 ft (6.1 m)


Conduit Supported at the Top
C
20 ft (6 m)
Threaded Coupling
Conduit Support at the Bottom

Horizontal Runs through Framing Members

A Horizontal runs of RMC, IMC, and EMT that are supported by openings through framing members (at intervals not greater than 10 ft [3 m]) and are fastened securely within 3 ft (900 mm) of termination points are permitted »*342.30(B)(4)*, *344.30(B)(4)*, and *358.30(B)*«.


Supported, but Not Fastened
3 ft (900 mm)
10 ft (3 m) or less
A

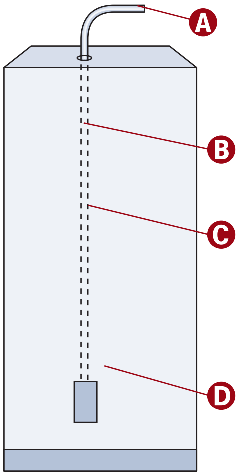
EMT Fished in Walls

A For concealed work in finished buildings (or prefinished wall panels) where standard securing is impracticable, unbroken lengths (without coupling) of electrical metallic tubing can be fished »*358.30(A) Exception No. 2*«.

B To comply with this exception, the fished portion of tubing in the wall must not have any couplings.

C Normally, EMT must be fastened within 3 ft (900 mm) of device boxes.

D Finished wall provides no access to secure tubing.



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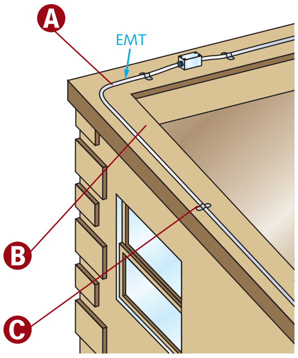
EMT Used as an Equipment Grounding Conductor

Ⓐ EMT can serve as an equipment grounding conductor »*250.118(A)(4)* and *358.60*«.

Ⓑ A raceway used as the equipment grounding conductor, as provided in 250.118 and 250.134(1), must comply with 250.4(A)(5) or 250.4(B)(4) »*250.122(A)*«.

Ⓒ EMT must be supported according to 358.30 provisions.



Warning

Where raceways or cables are exposed to direct sunlight on or above rooftops, raceways or cables shall be installed a minimum distance above the roof to the bottom of the raceway or cable of ¾ in. (19 mm). Where the distance above the roof to the bottom of the raceway is less than ¾ in. (19 mm), a temperature adder of 33°C (60°F) shall be added to the outdoor temperature to determine the applicable ambient temperature for application of the correction factors in Table 310.15(B)(1)(1) or Table 310.15(B)(1)(2) »*310.15(B)(2)*«. *Type XHHW-2 insulated conductors shall not be subject to this ampacity adjustment* »*310.15(B)(2) & Exception*«.

Electrical Metallic Tubing: Type EMT

Ⓐ Electrical metallic tubing (EMT) is an unthreaded thin-wall raceway of circular cross section designed for the physical protection and routing of conductors and cables and for use as an equipment grounding conductor when appropriate fittings are installed »*Article 100*«. EMT is also referred to as thin wall.

Ⓑ EMT, the thinnest-walled classification of metal nonflexible raceways, provides protection from all but severe physical damage. Read 358.10 and 358.12 for additional information on uses (permitted and not permitted).

Ⓒ The minimum approved electrical trade size for EMT is ½ in. »*358.20(A)*«.

Note

The number of conductors permitted in EMT must not exceed the percentage fill specified in Table 1, Chapter 9 »***358.22***«.

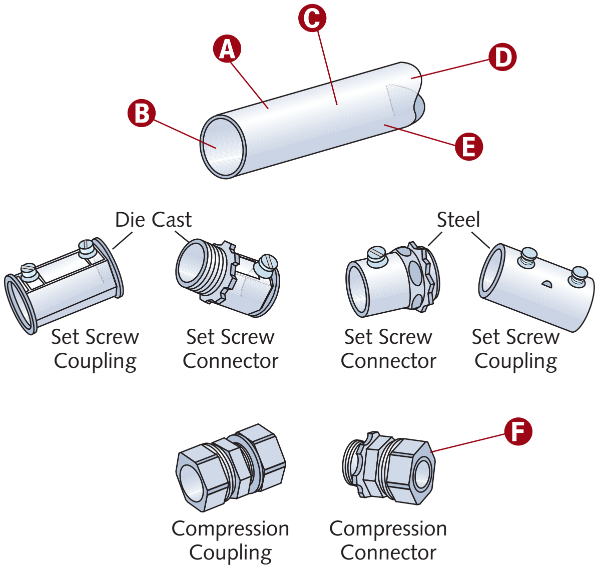
Note

Where practicable, dissimilar metals in contact anywhere in the system shall be avoided to eliminate the possibility of galvanic action. Stainless steel and aluminum fittings and enclosures shall be permitted to be used with galvanized steel EMT, and galvanized steel fittings and enclosures shall be permitted to be used with aluminum EMT where not subject to severe corrosive influences. Stainless steel EMT shall only be used with: stainless steel fittings, boxes, and enclosures; steel (galvanized, painted, powder or PVC coated, and so forth) boxes, and enclosures when not subject to severe corrosive influences; and stainless steel, nonmetallic, or approved accessories »***358.14***«.

Ⓓ The maximum approved electrical trade size for EMT is 6 in. »*358.20(B)*«.

Ⓔ All EMT cut ends must be reamed (or otherwise finished) to remove rough edges »*358.28(A)*«.

Ⓕ Couplings and connectors used with tubing must be made tight. Buried in masonry (or concrete), they must be the concrete-tight type. Installed in wet locations, they must comply with 314.15 »*358.42*«.



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Rigid Polyvinyl Chloride Conduit: Type PVC

NEC **identifies five types of rigid PVC conduit:**

1. **Schedule 80 PVC is an extra-heavy-walled raceway with a wall thickness conforming to Schedule 80-Iron Pipe Size (IPS) dimensions.**
2. **Schedule 40 PVC is a heavy-walled raceway with a wall thickness conforming to Schedule 40-IPS dimensions.**
3. **Type A PVC is a thin-walled raceway with wall thickness conforming to Schedule A-IPS dimensions. Limited to underground installations, Type A PVC conduit must be laid with its entire length in concrete.**
4. **Type EB PVC is a thin-walled raceway with wall thickness designed to achieve a minimum pipe stiffness of 20 lbs./in./in. Type EB PVC conduit, limited to underground installations, must be laid with its entire length in concrete in outdoor trenches.**
5. **HDPE Schedule 40 is a high-density polyethylene raceway with a wall thickness conforming to Schedule 40-IPS dimensions. HDPE Schedule 40 conduit, also limited to underground installations, can be direct buried with or without being encased in concrete.**

A Rigid polyvinyl chloride (PVC) conduit is a rigid nonmetallic raceway of circular cross section, with integral or associated couplings, connectors, and fittings for the installation of electrical conductors and cables »*Article 100*«.

B All joints between lengths of conduit, and between conduit and couplings, fittings, and boxes, must be made by an approved method »*352.48*«.

C All cut ends must be trimmed inside and out to remove rough edges »*352.28*«.

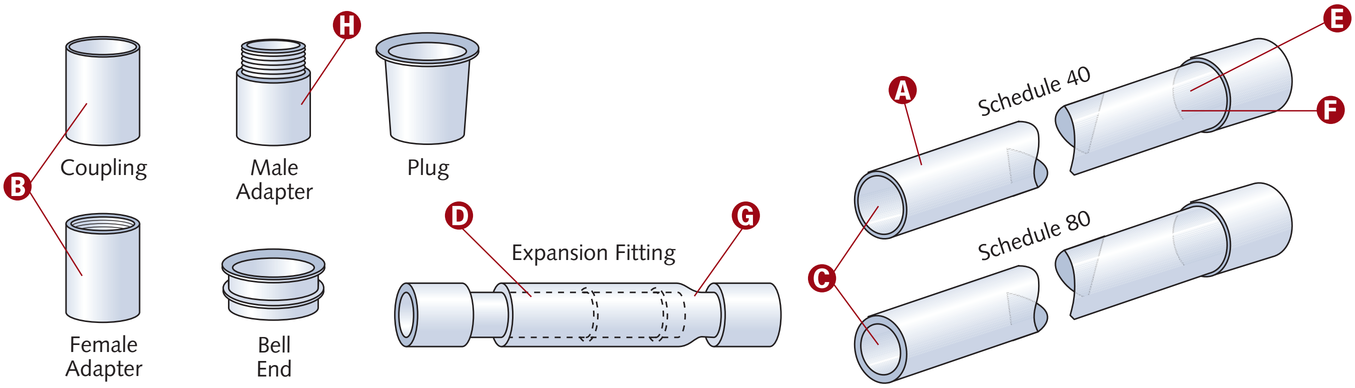
D Expansion fittings must be provided for PVC conduit to compensate for thermal expansion and contraction where the length change is expected to be ¼ in. (6 mm) or greater, in accordance with Table 352.44(A), in a straight run between securely mounted items such as boxes, cabinets, elbows, or other conduit terminations »*352.44(A)* and *300.7(B)*«.

E The minimum approved electrical trade size for PVC conduit is ½ in. »*352.20(A)*«.

F The maximum approved electrical trade size for PVC conduit is 6 in. »*352.20(B)*«.

G Expansion and contraction problems generally do not arise in underground PVC conduit applications.

H Only listed factory elbows and associated fittings shall be used with PVC conduit »*352.6*«.



Note

Where a raceway crosses a structural joint intended for expansion, contraction, or deflection, used in buildings, bridges, parking garages, or other structures, a listed expansion/deflection fitting or other approved means shall be used »*300.4(H)*«.

Caution

Where conductors or cables are rated at a temperature higher than the listed temperature rating of PVC conduit, it shall be permissible to install those conductors or cables in PVC conduit, but those conductors or cables must not be operated at a temperature higher than the listed temperature rating of the PVC conduit »*352.10(J)*«.

Note

Read 352.10 and 12 for a description of uses (permitted and not permitted) of rigid PVC conduit.

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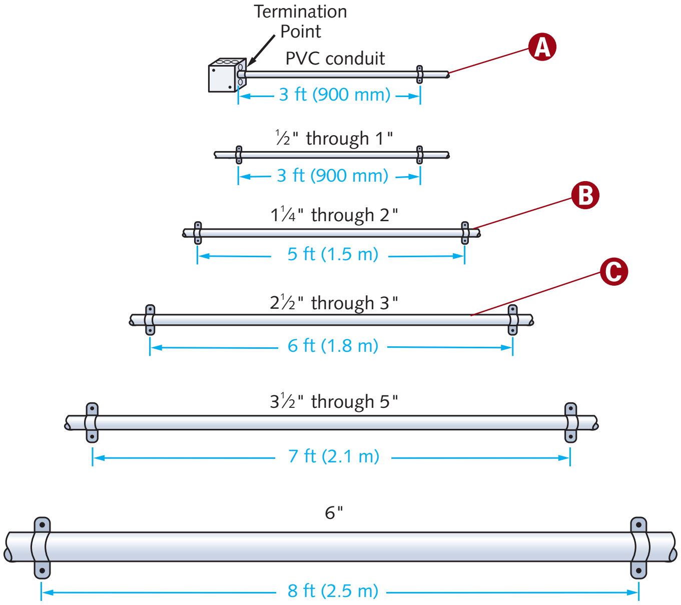
Securing Rigid PVC Conduit

Ⓐ Each conduit must be fastened securely within 3 ft (900 mm) of all termination points »*352.30(A)*«.

Ⓑ Table 352.30(B) support provisions must be followed for PVC conduit »*352.30(B)*«.

Ⓒ PVC must be fastened so that movement from thermal expansion or contraction is permitted »*352.30*«.



Note

Horizontal runs of PVC that are supported by openings through framing members (at intervals not greater than those in Table 352.30(B)) and are securely fastened within 3 ft (900 mm) of termination points are permitted **»*352.30(B)*«**.

PVC conduit, listed for securing at other than 3 ft (900 mm), can be installed in accordance with the listing **»*352.30(A)*«**.

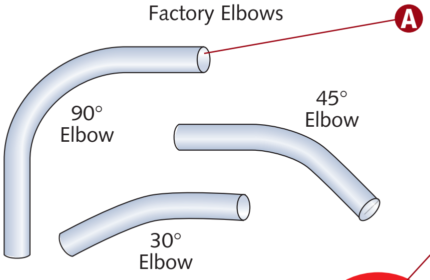
Bending Rigid PVC Conduit

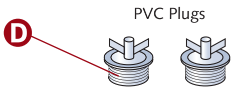
Ⓐ PVC bends must be made so that the conduit remains undamaged and the internal diameter of the conduit is not reduced »*352.24(A)*«.

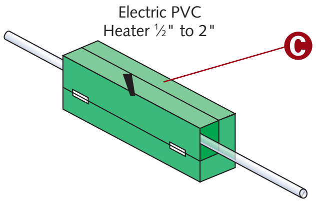
Ⓑ The conduit must not be damaged.

Ⓒ Field bends must be made only with identified bending equipment. The radius of the curve to the centerline of such bends must not be less than shown in Table 2 of Chapter 9 »*352.24(A)*«.

Ⓓ Installing PVC plugs in the ends of larger conduits (2 to 6 in.) can prevent conduit collapses or other deformities.

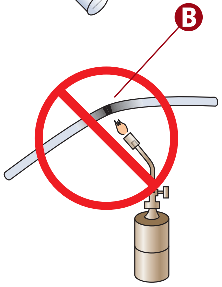






Caution

Field bends shall be made with identified bending equipment.



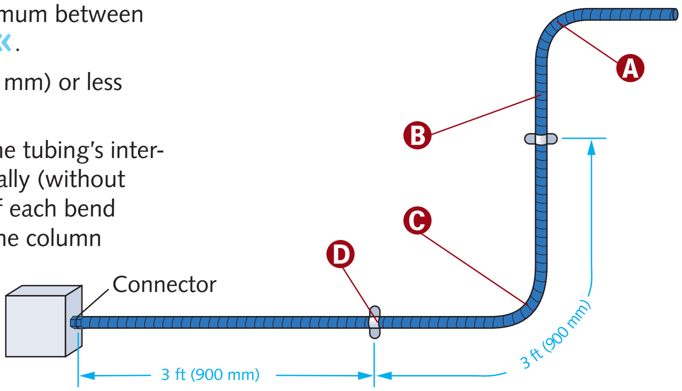
Securing Electrical Nonmetallic Tubing (ENT)

Ⓐ The equivalent of four quarter bends (360° total) is the maximum between pull points, for example, conduit bodies and boxes »*362.24(B)*«.

Ⓑ Electrical nonmetallic tubing must be secured every 3 ft (900 mm) or less »*362.30(A)*«.

Ⓒ Bends must be made so that the tubing is undamaged and the tubing's internal diameter is not reduced. Although bends can be made manually (without auxiliary equipment), the radius of the curve of the inner edge of each bend must not be less than shown in Table 2 of Chapter 9 and using the column titled "Other Bends" »*362.24(A)*«.

Ⓓ ENT must be fastened securely within 3 ft (900 mm) of each outlet box, device box, junction box, cabinet, or other termination point »*362.30(A)*«.



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Electrical Nonmetallic Tubing: Type ENT

For the complete listing of ENT uses (permitted and not permitted), read 362.10 and 362.12.

A Electrical nonmetallic tubing (ENT) is a nonmetallic pliable corrugated raceway of circular cross section with integral (or associated) couplings, connectors, and fittings listed for the installation of electrical conductors. It is composed of a material that is flame-retardant as well as resistant to moisture and chemical atmospheres »*Article 100*«.

B All cut ends must be trimmed inside and out to remove rough edges »*362.28*«.

C The minimum approved electrical trade size for ENT is ½ in. »*362.20(A)*«.

D The maximum approved electrical trade size for ENT is 2½ in. »*362.20(B)*«.

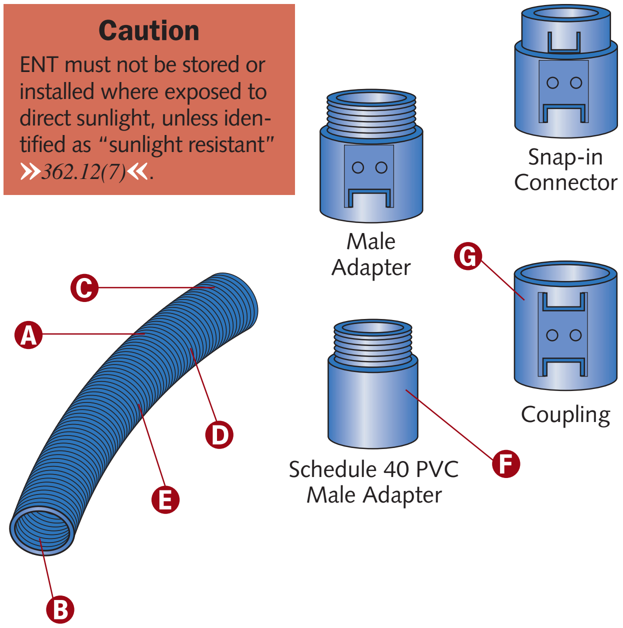
E A pliable raceway can be bent by hand with reasonable force, but without other assistance »*Article 100*«.

F Outside diameters are such that standard rigid PVC conduit couplings and connectors can be used on ENT of PVC construction. ENT installation instructions outline the procedure to follow when installing PVC conduit fittings that are cemented in place. Specific cement requirements and application methods are provided.

G An approved method must be used for all joints between lengths of tubing and between tubing and couplings, fittings, and boxes »*362.48*«.

Caution

ENT must not be stored or installed where exposed to direct sunlight, unless identified as "sunlight resistant" »*362.12(7)*«.



Note

ENT must comply with 300.4 protection requirements.

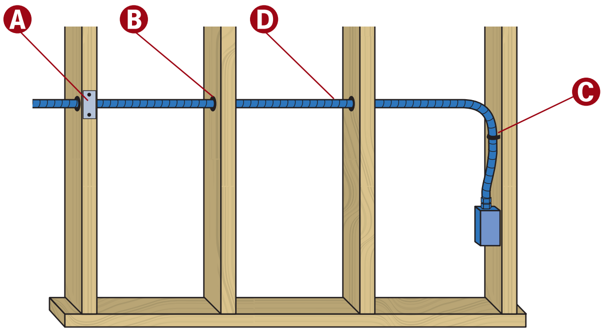
ENT through Framing Members

A If the bored hole is less than 1¼ in. (32 mm) from the edge of the framing member, the raceway must be protected from penetration (by screws, nails, etc.) by a steel plate(s) or bushing(s). The steel plate must be at least 1⁄16 in. (1.6 mm) thick and of appropriate length and width to adequately cover the wiring »*300.4(A)(1)*«.

B Holes must be bored so that the edge of the hole is at least 1¼ in. (32 mm) from the nearest edge of the wood member »*300.4(A)(1)*«.

C ENT must be securely fastened in place within 3 ft (900 mm) of all termination points »*362.30(A)*«.

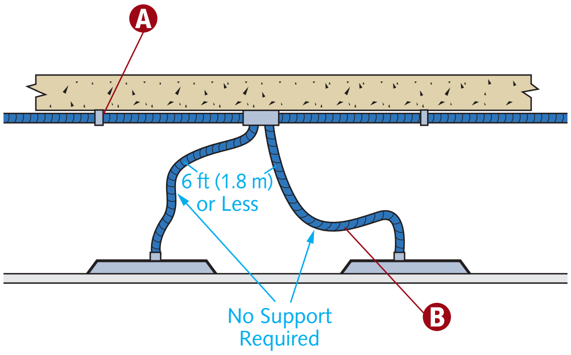
D Horizontal runs of ENT can be supported by openings through framing members at intervals not greater than 3 ft (900 mm) »*362.30(B)*«.



ENT Luminaire Whips

A ENT must be secured within 3 ft (900 mm) of all termination points »*362.30(A)*«.

B Securing is not required for ENT in lengths not more than 6 ft (1.8 m) from a luminaire terminal connection (for tap connections to luminaires) »*362.30(A) Exception No. 1*«.



Note

Where used, cable ties shall be listed for the application and for securing and supporting »***362.30(A)***«.

Note

Securing is not required for ENT in lengths not exceeding 6 ft (1.8 m) from the last point of support for connections within an accessible ceiling to luminaire(s) or other equipment »***362.30(A) Exception No. 2***«.

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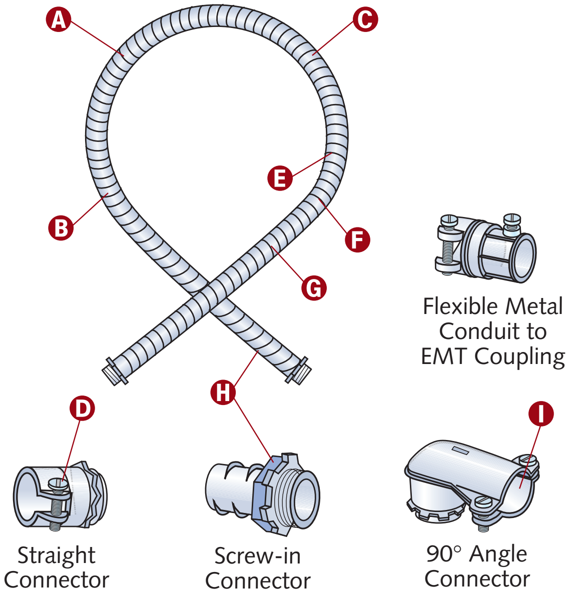
Flexible Conduit

Flexible Metal Conduit: Type FMC



A Flexible metal conduit (FMC) is a raceway of circular cross section made of helically wound, formed, and interlocked metal strip »*Article 100*«. FMC must be listed and can be used in both exposed and concealed locations »*348.6* and *348.10*«.

B The minimum electrical trade size for FMC is ½ in., unless a 348.20(A) provision is met.

C Flexible metal conduit is often referred to as *Greenfield*, or simply *flex*.

D Fittings used with FMC must be listed »*348.6*«.

E The maximum approved electrical trade size for FMC is 4 in. »*348.20(B)*«.

F The equivalent of four quarter bends (360° total) is the maximum between pull points, for example, conduit bodies and boxes »*348.24(B)*«.

G Bends must be made so that the conduit is not damaged and the conduit's internal diameter is not effectively reduced. The radius of the curve of the inner edge of any field bend must not be less than shown in Table 2 of Chapter 9 using the column titled "Other Bends" »*348.24(A)*«.

H All cut ends must be trimmed (or otherwise finished) to remove rough edges, except where fittings are used that thread into the convolutions »*348.28*«.

I Angle connectors shall not be used for concealed raceway installations »*348.42*«.

Note

For areas where FMC is not allowed, see 348.12.

FMC Support

Support is not required for fished FMC »*348.30(A) Exception No. 1*«.

A FMC must be fastened securely in place (by an approved means) at intervals of 4½ ft (1.4 m) or less »*348.30(A)*«.

B FMC must be secured within 12 in. (300 mm) of each box, cabinet, conduit body, or other conduit termination »*348.30(A)*«.

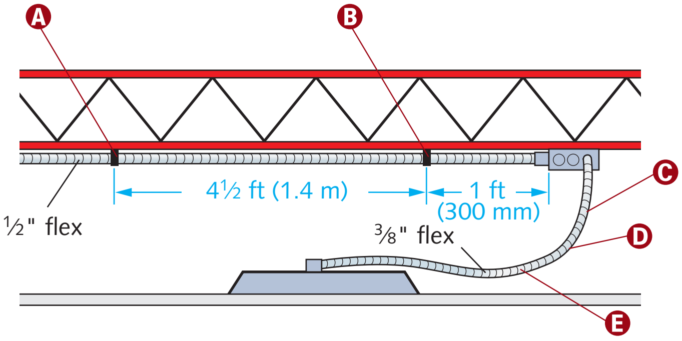
C Refer to Table 348.22 for the maximum number of conductors permitted in ⅜ in. flex.

D If the length of FMC from a luminaire terminal for tap connections, as permitted in 410.117(C), to luminaires is 6 ft (1.8 m), or less, supporting is not required »*348.30(A) Exception No. 3*«.

Note

Where used, cable ties shall be listed and be identified for securement and support »***348.30(A)***«.

E FMC of ⅜ in. electrical trade size can be used (1) for enclosing the leads of motors as permitted in 430.245(B); (2) in lengths not in excess of 6 ft (1.8 m) as part of a listed assembly, for tap connections to luminaires as permitted in 410.117(C), or for utilization equipment; (3) for manufactured wiring systems as permitted in 604.100(A); (4) in hoistways, as permitted in 620.21(A)(1); or (5) as part of a listed assembly to connect wired luminaire sections as permitted in 410.137(C) »*348.20(A)*«.



Note

Horizontal runs of FMC can be supported by openings through framing members (at intervals not greater than 4½ ft [1.4 m]), if securely fastened within 12 in. (300 mm) of each termination point »***348.30(B)***«.

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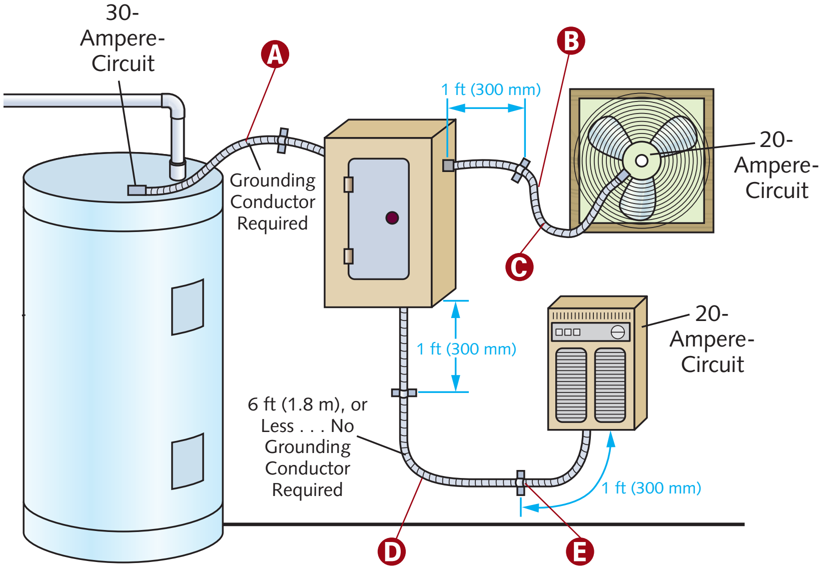
FMC Installation


30-
Ampere-
Circuit
A
B
1 ft (300 mm)
20-
Ampere-
Circuit
Grounding
Conductor
Required
C
1 ft (300 mm)
20-
Ampere-
Circuit
6 ft (1.8 m), or
Less . . . No
Grounding
Conductor
Required
1 ft (300 mm)
D
E

A Equipment grounding conductors are required for circuits over 20 amperes »*250.118(A)(5)*«

B Where flexibility is necessary after installation, lengths from the last point where the raceway is securely fastened shall not exceed the following: 3 ft (900 mm) for trade sizes ½ through 1¼ (metric designators 16 through 35); 4 ft (1200 mm) for trade sizes 1½ through 2 (metric designators 41 through 53); and 5 ft (1500 mm) for trade size 2½ (metric designator 63) and larger »*348.30(A) Exception No. 2*«.

C If an equipment bonding jumper is required around FMC, it must be installed in accordance with 250.102 »*348.60(D)*«.

D Listed FMC can serve as a grounding means if (1) the conduit is terminated in listed fittings; (2) the circuit conductors contained therein are protected by overcurrent devices rated at 20 amperes or less; (3) the size of the conduit does not exceed trade size 1¼; (4) the total length in any ground-fault current path is 6 ft (1.8 m) or less; and (5) the conduit is not installed where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement »*250.118(A)(5)*«.

E FMC must be secured within 12 in. (300 mm) of each box, cabinet, conduit body, or other conduit termination »*348.30(A)*«.

Caution

An equipment grounding conductor must be installed in FMC used to connect equipment where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation »*348.60(B)*«.

Liquidtight Flexible Metal Conduit: Type LFMC

The equivalent of four quarter bends (360° total) is the maximum allowed between pull points, for example, conduit bodies and boxes »*350.24(B)*«.

A Liquidtight flexible metal conduit (LFMC) is a raceway of circular cross section having an outer liquidtight, nonmetallic, sunlight-resistant jacket over an inner flexible metal core with associated couplings, connectors, and fittings for the installation of electric conductors »*Article 100*«.

B The minimum electrical trade size for LFMC is ½ in., except as provided in 348.20(A) »*350.20(A)*«. The number of conductors allowed in ⅜ in. conduit must not exceed the limit set in Table 348.22, "Fittings Outside Conduit" columns »*350.22(B)*«.

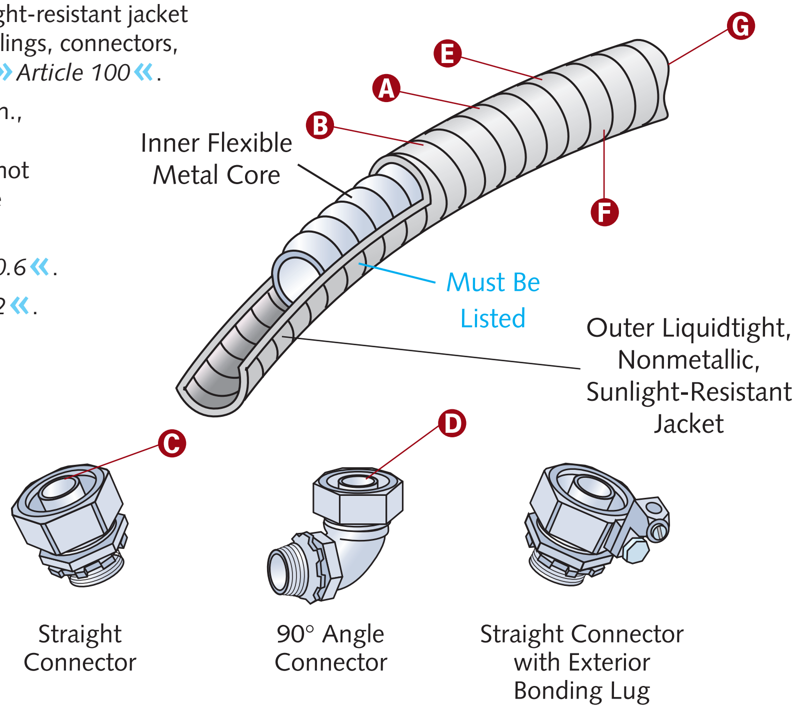
C LFMC and associated fittings must be listed »*350.6*«.

D Angle connectors shall not be concealed »*350.42*«.

E The maximum approved electrical trade size for LFMC is 4 in.»*350.20(B)*«.

F LFMC is often referred to as *Sealtite* (a registered trademark).

G All cut ends of conduit shall be trimmed inside and outside to remove rough edges »*350.28*«.


G
E
A
B
Inner Flexible
Metal Core
F
Must Be
Listed
Outer Liquidtight,
Nonmetallic,
Sunlight-Resistant
Jacket
C
D
Straight
Connector
90° Angle
Connector
Straight Connector
with Exterior
Bonding Lug

Note

Securing and support requirements for LFMC are listed in 350.30.

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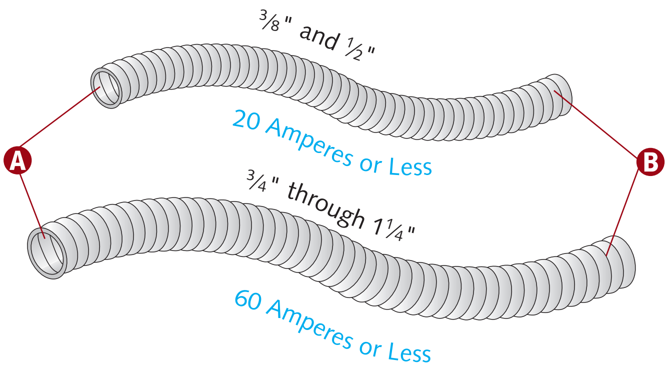
Grounding Liquidtight Flexible Metal Conduit

A Listed LFMC, ⅜ in. through 1¼ in., can be used as a grounding means if (1) the total length of flexible conduit in any ground-fault current path is not more than 6 ft (1.8 m); (2) the conduit is terminated in listed fittings; and (3) the circuit conductors contained therein are protected by overcurrent devices rated at 20 amperes or less for ⅜-in. and ½-in. electrical trade sizes and 60 amperes or less for ¾-in. through 1¼-in. electrical trade sizes »*250.118(A)(6)*«.

B LFMC can serve as a grounding means as covered in 250.118(A)(6). If an equipment bonding jumper is required around LFMC, it must be installed in accordance with 250.102 »*350.60(D)*«.



Caution

LFMC used to connect equipment, where flexibility is necessary to minimize the transmission of vibration from equipment or to provide flexibility for equipment that requires movement after installation, must have an equipment grounding conductor »*350.60* and *250.118(A)(6)e*«.

Note

An equipment bonding jumper can be installed either inside or outside of a raceway. If installed on the raceway's exterior, the jumper shall not exceed 6 ft (1.8 m) in length and must be routed with the raceway ***»250.102(E)* and *250.102(E)(2)*«**.

Liquidtight Flexible Nonmetallic Conduit: Type LFNC

The equivalent of four quarter bends (360° total) is the maximum allowed between pull points, for example, conduit bodies and boxes »*356.24(B)*«.

A Liquidtight flexible nonmetallic conduit (LFNC) is a raceway of circular cross section of various types, including LFNC-A, LFNC-B, and LFNC-C »*Article 100*«.

B Type LFNC-A has a smooth seamless inner core and cover bonded together and one or more reinforcement layers between the core and covers »*Article 100*«.

C Type LFNC-B has a smooth inner surface having integral reinforcement within the raceway wall »*Article 100*«. (Outside appearance is similar to LFMC.)

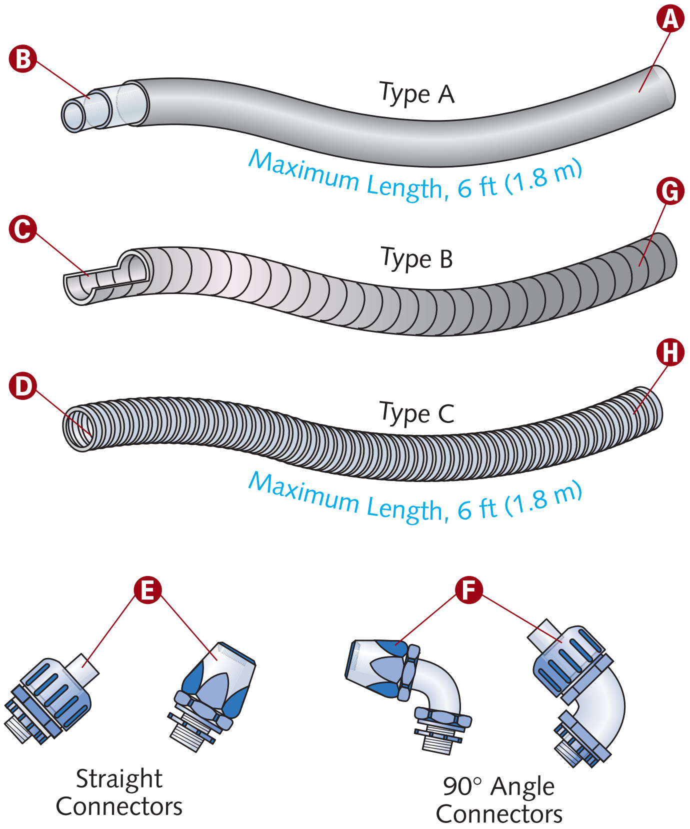
D Type LFNC-C has a corrugated internal and external surface having no integral reinforcement within the raceway wall »*Article 100*«. (Appearance is similar to ENT, except more flexible.)

E LFNC and associated fittings must be listed »*356.6*«.

F Angle connectors shall not be used for concealed raceway installations »*356.42*«.

G The maximum approved electrical trade size for LFNC is 4 in. »*356.20(B)*«.

H The minimum electrical trade size for LFNC is ½ in., unless a 356.20(A) provision applies.



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Liquidtight Flexible Nonmetallic Conduit Installation

Strapping is not required for LFNC lengths of 6 ft (1.8 m) or less from a luminaire terminal connection for tap conductors to luminaires as permitted in 410.117(C) »*356.30(2)*«.

Support is not required for fished LFNC »*356.30(2)*«.

Where used, cable ties shall be listed for the application and for securing and supporting »*356.30(1)*«.

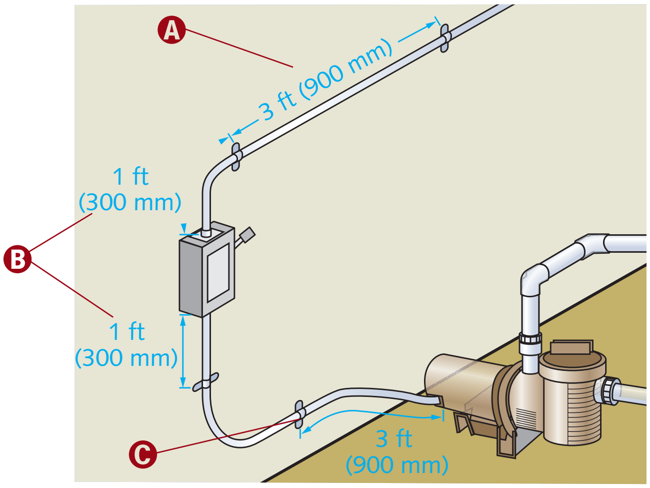
Horizontal runs of LFNC can be supported by openings through framing members [at intervals not greater than 3 ft (900 mm)], if securely fastened within 12 in. (300 mm) of each termination point »*356.30(3)*«.

Securing and supporting is not required for LFNC where installed in lengths not exceeding 6 ft (1.8 m) from the last point of support for connections within an accessible ceiling to luminaire(s) or other equipment. For the purpose of 356.30, listed liquidtight flexible nonmetallic conduit fittings shall be permitted as a means of support »*356.30(4)*«.

A LFNC must be securely fastened at intervals not greater than 3 ft (900 mm) »*356.30(1)*«.

B LFNC must be secured within 12 in. (300 mm) of each connection to every outlet box, junction box, cabinet, or fitting »*356.30(1)*«.

C Where flexibility is necessary, LFNC can be secured within 3 ft (900 mm) of the termination »*356.30(2)*«.



Note

Where equipment grounding is required, a separate equipment grounding conductor must be installed in the conduit »*356.60*«. All conductors of the same circuit, including equipment grounding conductors, must be contained within the same raceway »*300.3(B)*«.

Other Raceways

Surface Nonmetallic Raceways

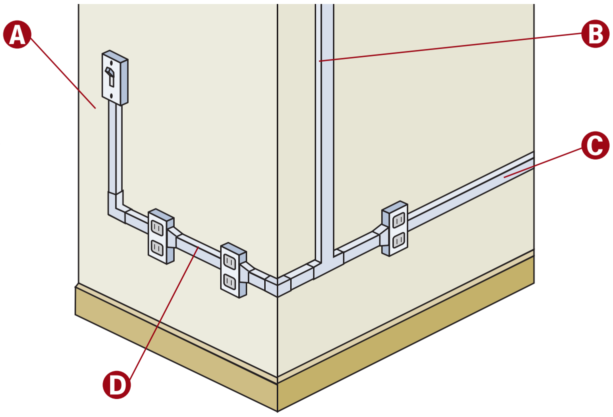
Where surface nonmetallic raceways are used in combination for both signaling and for lighting and power circuits, the different wiring systems must be run in separate compartments identified by stamping, imprinting, or color coding of the interior finish »*388.70*«.

A Surface nonmetallic raceway construction must be visibly distinguishable from other raceways. Surface nonmetallic raceways and their fittings must be designed so that sections can be mechanically coupled together and installed without subjecting the wires to abrasion »*388.100*«.

B The size and number of conductors installed in any raceway must not exceed the raceway's design limitations »*388.21* and *388.22*«.

C Splices and taps are permitted within surface nonmetallic raceway having a removable cover that remains accessible once installed. The conductors, at the point of splices and taps, must not fill the raceway to more than 75% of its area. Splices and taps in surface nonmetallic raceways without covers capable of being opened in place must be made only in boxes. All splices and taps must be made using approved methods »*388.56*«.

D Surface nonmetallic raceways can be installed in dry locations »*388.10(1)*«. *NEC* 388.12 lists the locations where these raceways shall not be used.



Note

Unbroken lengths of surface nonmetallic raceways can pass transversely through dry walls, partitions, and floors. Conductors must be accessible on both sides of the wall, partition, or floor »*388.10(2)*«.

Where equipment grounding is required, a separate equipment grounding conductor must be installed within the raceway »*388.60*«.

Surface Metal Raceways

A Surface metal raceway construction must be distinguishable from other raceways. Surface metal raceways and their fittings must be designed so that the sections can be electrically and mechanically coupled together and installed without subjecting the wires to abrasion. Nonmetallic covers and accessories can be used on surface metal raceways only if identified for such use *»386.100«*.

B Uses (permitted and not permitted) are located in 386.10 and 386.12.

C The number and size of conductors installed in any raceway must not exceed the raceway's design limitations *»386.21* and *386.22«*.

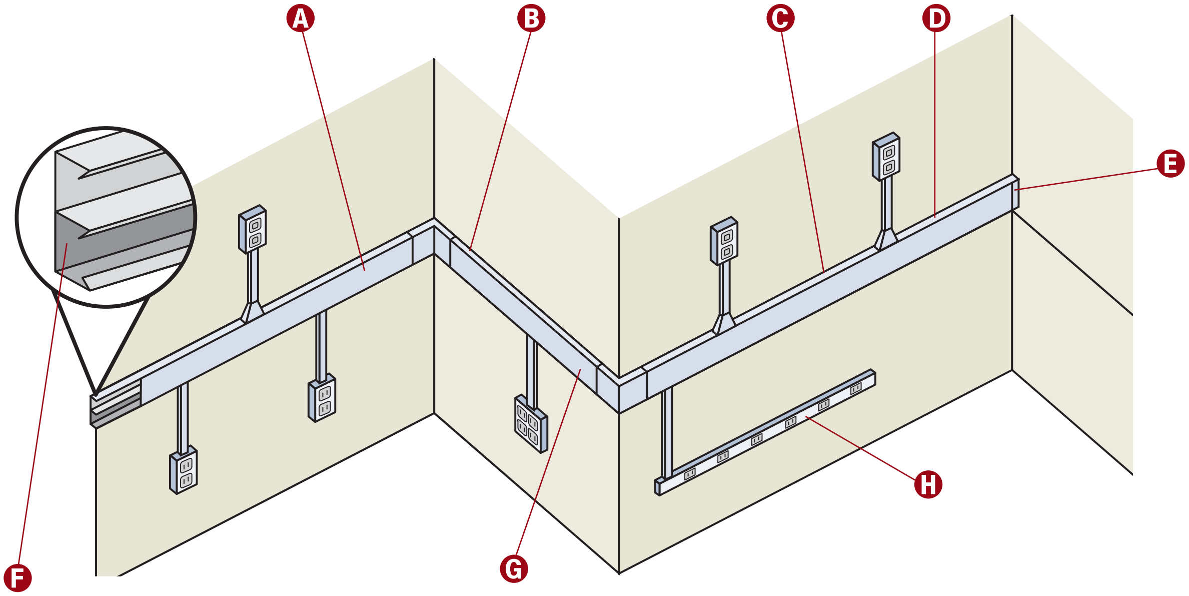
D The adjustment factors of 310.15(C)(1) do not apply to conductors installed in surface metal raceways where all of the following conditions are met: (1) the cross-sectional area of the raceway exceeds 4 in.^{2} (2500 mm^2); (2) the current-carrying conductors do not exceed 30 in number; and (3) the sum of the cross-sectional areas of all contained conductors does not exceed 20% of the interior cross-sectional area of the surface metal raceway *»386.22«*.

E Unbroken lengths of surface metal raceway can pass transversely through dry walls, dry partitions, and dry floors. Access to the conductors must be maintained on both sides of the wall, partition, or floor *»386.10(4)«*.

F Where surface metal raceways are used in combination for both signaling and for lighting and power circuits, the different wiring systems must be run in separate compartments identified by stamping, imprinting, or color coding of the interior finish *»386.70«*.

G Splices and taps are permitted within surface metal raceway having a removable cover that remains accessible after installation. At the point of splices and taps, the conductors must not fill the raceway to more than 75% of its area. Splices and taps in surface metal raceways without removable covers can be made only in boxes. Use only approved methods for splices and taps *»386.56«*.

H Multioutlet assemblies are covered in Article 380.



Note

If a surface metal raceway enclosure provides a transition from another wiring method, it must have a means to connect an equipment grounding conductor ***»386.60«***.

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Strut-Type Channel Raceways

Use Table 384.22 to determine the maximum number of conductors or cables permitted in strut-type channel raceway. Apply the appropriate Chapter 9 Tables for the cross-sectional area of the type and size of wire used »*384.22*«.

The adjustment factors of 310.15(C)(1) do not apply to conductors installed in strut-type channel raceways where all of the following conditions are met: (1) the cross-sectional area of the raceway exceeds 4 in.^{2} (2500 mm^2); (2) the current-carrying conductors do not exceed 30 in number; and (3) the sum of the cross-sectional areas of all contained conductors does not exceed 20% of the interior cross-sectional area of the strut-type channel raceway »*384.22*«.

Conductors larger than that for which the strut-type channel raceway is listed must not be used »*384.21*«.

A surface mount strut-type channel raceway must be secured to the mounting surface with external retention straps at intervals not exceeding 10 ft (3 m), and within 3 ft (900 mm) of each raceway termination (outlet box, cabinet, junction box, etc.) »*384.30(A)*«.

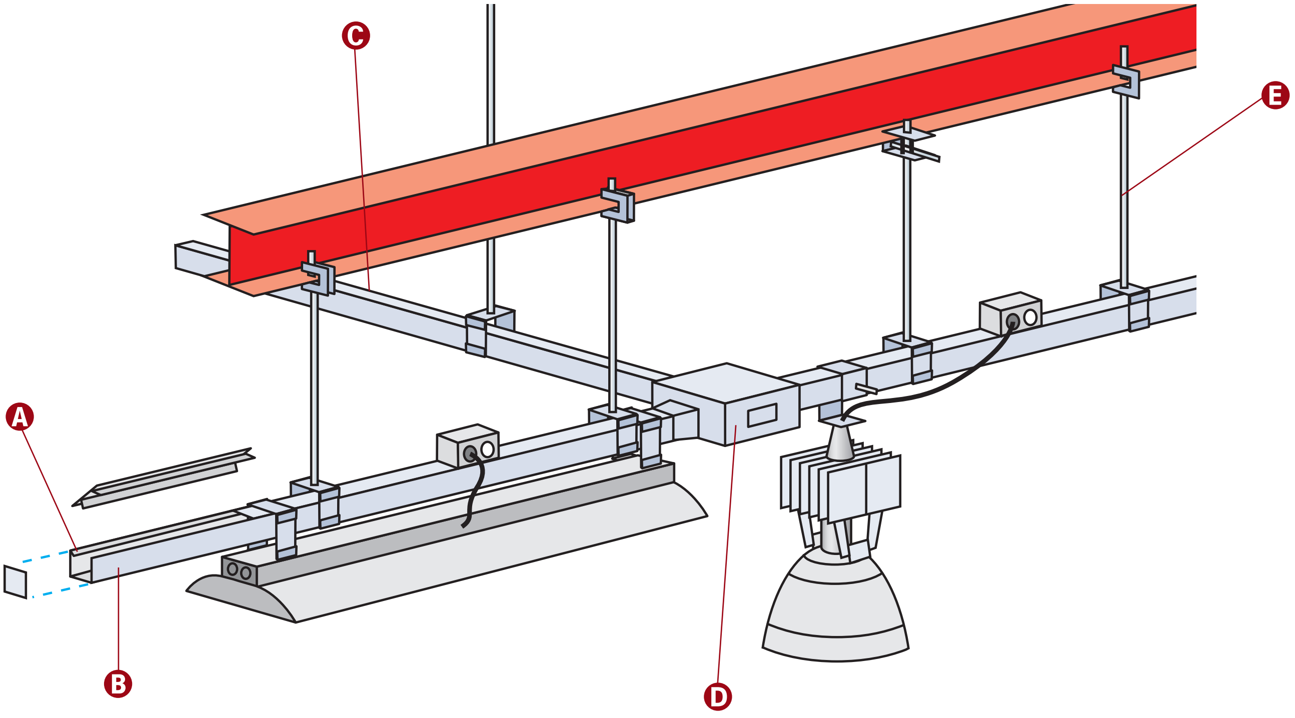
A Strut-type channel raceways and accessories must be listed and identified for such use »*384.6*«.

B Splices and taps are permitted in raceways that provide access after installation via a removable cover. At any point of splices or taps, the conductors must not fill the raceway to more than 75%. All splices and taps must be made by approved methods »*384.56*«.

C Uses (permitted and not permitted) are covered in 384.10 and 384.12.

D Strut-type channel raceway enclosures providing a transition to (or from) other wiring methods must accommodate the connection of an equipment grounding conductor. A strut-type channel raceway can be used as an equipment grounding conductor in accordance with 250.118(A)(13) »*384.60*«.

E Strut-type channel raceways shall be permitted to be suspension mounted in air with identified methods at intervals not to exceed 10 ft (3 m) and within 3 ft (900 mm) of channel raceway terminations and ends »*384.30(B)*«.



Note

Unbroken lengths of strut-type channel raceway can extend through walls, partitions, and floors provided closure strips are removable from either side and the portion within the wall, partition, or floor remains covered »*384.10(6)*«.

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Underfloor Raceways

An underfloor raceway is defined as a raceway and associated components designed and intended for installation beneath or flush with the surface of a floor for the installation of cables and electrical conductors »*Article 100*«.

A Connections between raceways and distribution centers and wall outlets must be made by approved fittings or by any of the wiring methods in Chapter 3, where installed according to the provisions of the respective articles »*390.76*«.

B Underfloor raceways can be installed beneath a concrete (or other flooring material) surface. In office occupancies, installations flush with the concrete floor and covered with linoleum (or equivalent covering) are acceptable »*390.10*«.

C The combined cross-sectional area of all conductors or cables must not exceed 40% of the interior cross-sectional area of the raceway »*390.22*«.

D The size of conductors installed must not be larger than that for which the underfloor raceway is designed »*390.20*«.

E Inserts must be leveled and sealed to prevent the entrance of concrete. Metal raceway inserts must also be metal and must be electrically continuous with the raceway »*390.75*«.

Caution

When an outlet is abandoned, discontinued, or removed, the supplying circuit conductors must be removed from the raceway. Splices or reinsulated conductors, such as would occur in the case of abandoned outlets on loop wiring, are not allowed in raceways »*390.57*«.

F Seal and level junction boxes to the floor grade to prevent entrance of water or concrete. Underfloor metal raceway junction boxes must also be metal and must be electrically continuous with the raceway »*390.74*«.

G Splices and taps are acceptable only within junction boxes. Continuous, unbroken conductor connecting the individual outlets (so-called loop wiring) is not considered a splice or tap »*390.56*«.

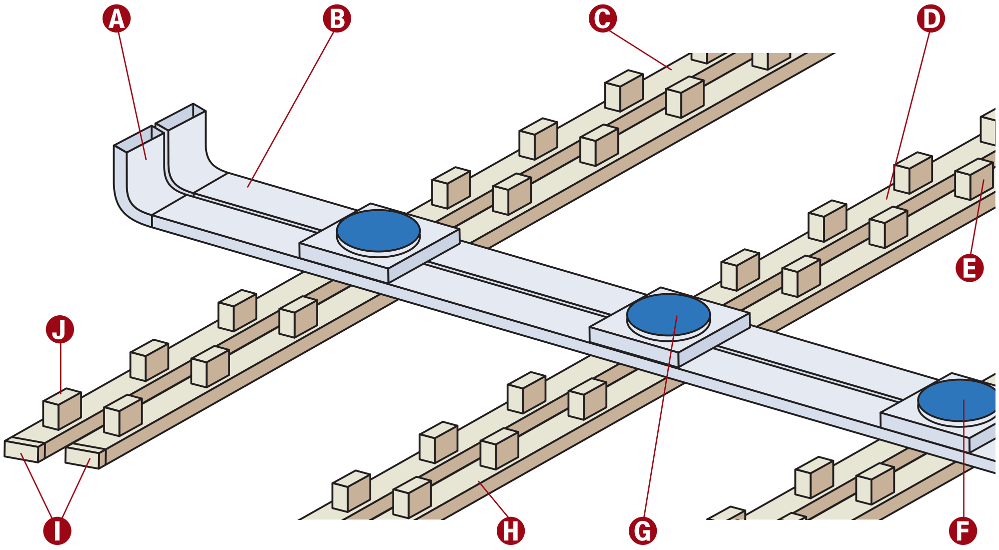
H Underfloor raceways must be laid so that a straight line from the center of one junction box to the center of the next junction box coincides with the centerline of the raceway system. Raceways must be held firmly in place to prevent misalignment during construction »*390.70*«.

I Raceway dead ends must be closed »*390.73*«.

J Install a suitable marker at, or near, each end of straight raceway runs to locate the last insert »*390.71*«.

Note

390.12 lists areas where underfloor raceways are not permitted.



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Underfloor Raceway Covering

A Half-round and flat-top raceways not over 4 in. (100 mm) in width must be covered by ¾ in. (20 mm) or more of concrete (or wood) »*390.15(A)*«.

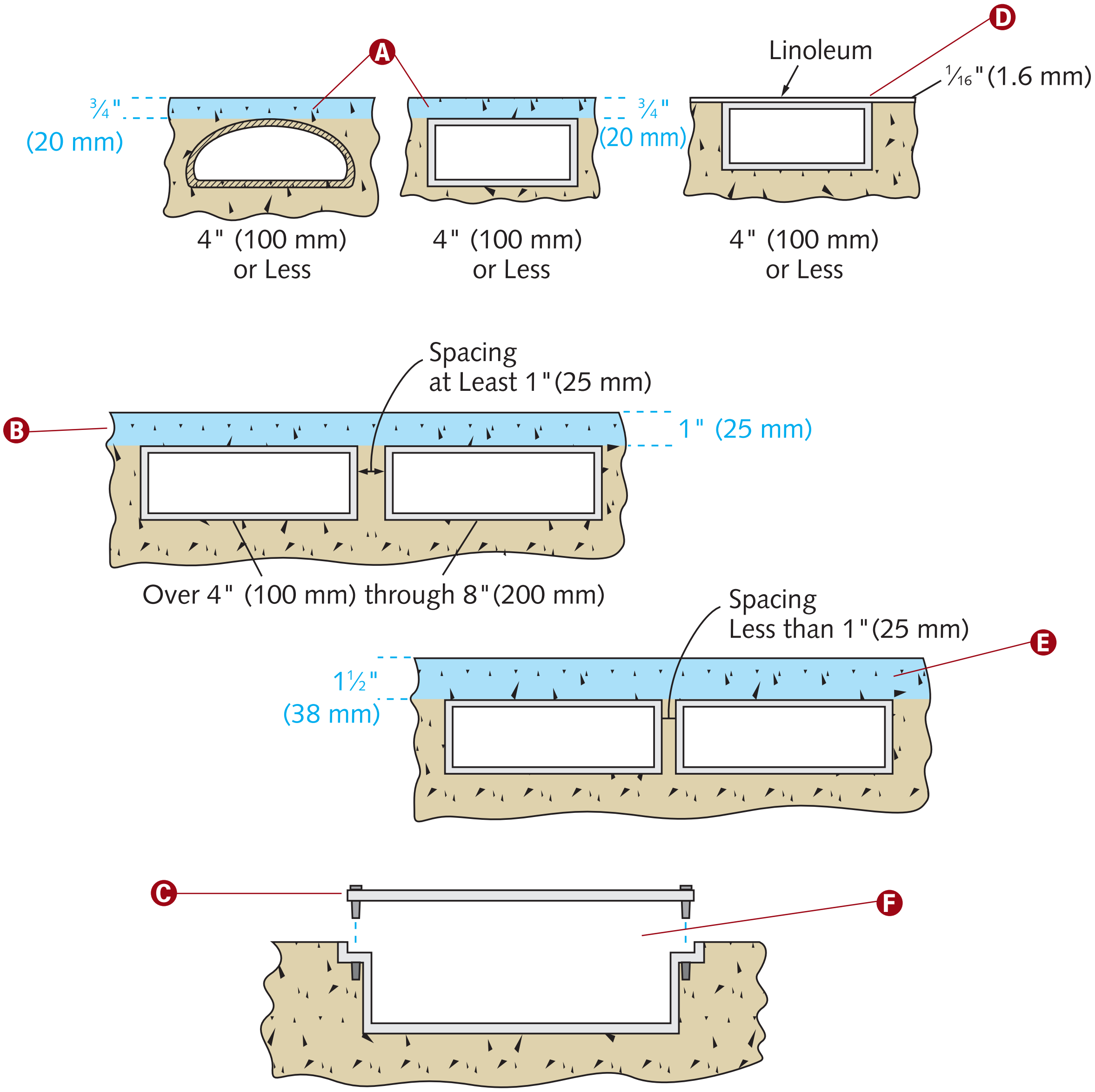
B Flat-top raceways greater than 4 in. (100 mm) but not more than 8 in. (200 mm) wide, with a minimum of 1 in. (25 mm) spacing between the raceways, must be covered with at least 1 in. (25 mm) of concrete »*390.15(B)*«.

C Trench-type flush raceways having removable covers can be laid flush with the floor's surface. Such approved raceways shall be designed so that the cover plates provide adequate mechanical protection and rigidity equivalent to junction box covers »*390.15(C)*«.

D In office occupancies, approved flat-top metal raceways (of 4 in. [100 mm] or less in width) can be flush with the concrete floor surface, provided they are covered with a minimum 1⁄16-in. (1.6-mm) floor covering, such as linoleum. Where more than one (but fewer than four) single raceways are installed flush with the concrete, they must be contiguous with one another and be joined forming a rigid assembly »*390.15(D)*«.

E Flat-top raceways greater than 4 in. (100 mm) but not more than 8 in. (200 mm) wide that are spaced less than 1 in. (25 mm) apart must be covered with at least 1½ in. (38 mm) of concrete »*390.15(B)*«.

F Splices and taps are permitted in trench-type flush raceways whose removable covers are accessible after installation. At the point of any splices or taps, the conductors must not fill more than 75% of the raceway's area »*390.56 Exception*«.



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Cellular Metal Floor Raceways

A The combined cross-sectional area of all conductors or cables must not exceed 40% of the cell or header's interior cross-sectional area »*374.22*«.

B Junction boxes must be leveled to the floor grade and sealed against the entrance of water or concrete. Junction boxes used with these raceways must be metal and must be electrically continuous with the raceway »*374.18(B)*«.

C A cellular metal floor raceway is defined as the hollow spaces of cellular metal floors, together with suitable fittings, that may be approved as enclosed channel for electric conductors »*Article 100*«.

D Conductors larger than 1/0 AWG can be installed only by special permission »*374.20*«.

E Inserts must be leveled to the floor grade and sealed against the entrance of concrete. Only metal inserts can be used with metal raceways, and each must be electrically continuous with the raceway »*374.18(C)*«.

F Connections between raceways and distribution centers and wall outlets shall be made by means of liquidtight flexible metal conduit, flexible metal conduit where not installed in concrete, rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or approved fittings. Where there are provisions for the termination of an equipment grounding conductor, rigid polyvinyl chloride conduit, reinforced thermosetting resin conduit, electrical nonmetallic tubing, or liquidtight flexible nonmetallic conduit shall be permitted. Where installed in concrete, liquidtight flexible metal conduit and liquidtight flexible nonmetallic conduit shall be listed and marked for direct burial »*374.18(A)*«.

G Splices and taps are made only in header access units or junction boxes. Continuous, unbroken conductor connecting the individual outlets (so-called loop wiring) is not considered a splice or tap »*374.56*«.

H A "header" is a transverse metal raceway for electric conductors, providing access to predetermined cells of a precast cellular concrete floor, accommodating the installation of electric conductors from a distribution center to the cells »*Article 100*«.

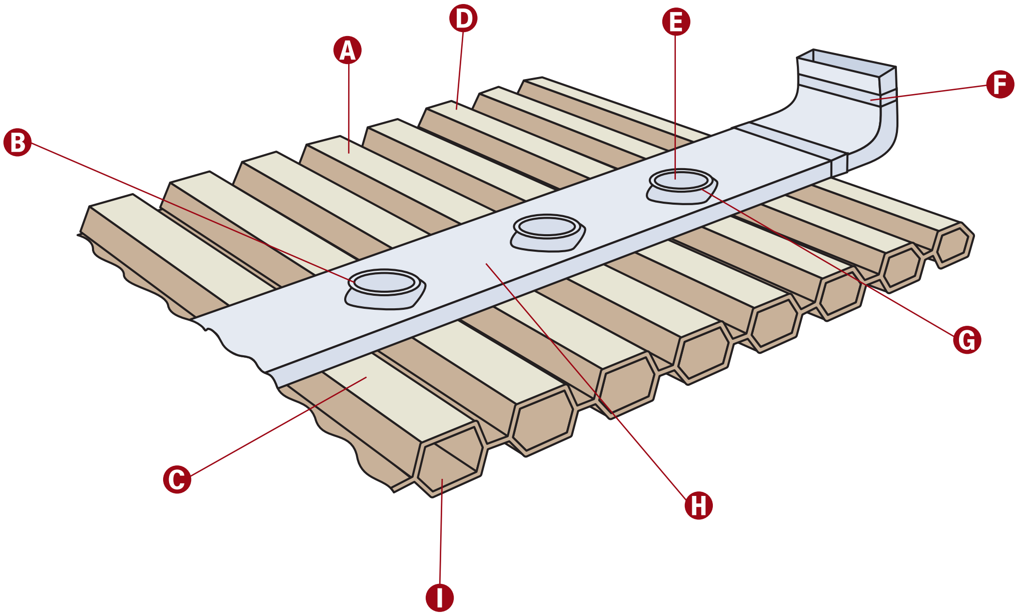
I A "raceway cell" is a single, enclosed tubular space in a cellular metal or concrete floor member, the axis of the cell being parallel to the axis of the floor member »*Article 100*«.

Note

Section 374.12 lists areas where cellular metal floor raceways shall not be used.

Caution

When an outlet is removed, abandoned, or discontinued, remove the section of circuit conductors supplying the outlet from the raceway. Raceways must not contain splices or reinsulated conductors as would occur with abandoned outlet loop wiring »*374.58*«.



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Cellular Concrete Floor Raceways

A Splices and taps are allowed only in header access units or junction boxes. A continuous unbroken conductor connecting the individual outlets is not a splice or tap »*372.56*«.

B A "header" is a transverse metal raceway for electric conductors that provides access to predetermined cells of a precast cellular concrete floor and permits the installation of conductors from a distribution center to the floor cells »*Article 100*«.

C Inserts must be leveled and sealed against the entrance of concrete. Inserts must be metal and must be fitted with grounded-type receptacles. A grounding conductor must connect the insert receptacles to a positive ground connection on the header »*372.18(D)*«.

D The header must be installed in a straight line and at right angles to the cells »*372.18(A)*«.

E Mechanically secure the header to the top of the precast cellular concrete floor. The header must be electrically continuous throughout its entire length and must be electrically bonded to the distribution center enclosure »*372.18(A)*«.

F Conductors larger than 1/0 AWG can be installed only by special permission »*372.20*«.

Caution

When an outlet is removed, abandoned, or discontinued, remove the section of circuit conductors supplying the outlet from the raceway. Raceways must not contain splices or reinsulated conductors such as loop wiring of abandoned outlets »*374.58*«.

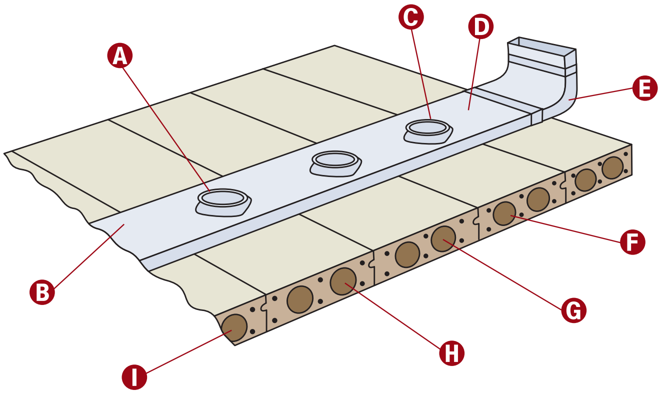
G The combined cross-sectional area of all conductors or cables must not exceed 40% of the cell or header's cross-sectional area »*372.22*«.

H A "raceway cell" is a single, enclosed tubular space in a cellular metal or concrete floor member, the axis of the cell being parallel to the axis of the floor member »*Article 100*«.

I Cellular concrete floor raceways are hollow spaces in floors constructed of precast cellular concrete slabs (together with suitable metal fittings) designed to provide access to the floor cells »*372.1*«.

Note

Section 374.12 lists areas where cellular metal floor raceways shall not be used.



Wireways (Metal and Nonmetallic)

A Wireways (sheet metal and flame-retardant, nonmetallic) are troughs with hinged or removable covers for housing and protecting electric wires (and cables). The complete raceway system is installed before conductors are laid in place »*Article 100*«.

B The sum of the cross-sectional area of all contained conductors or cables shall not exceed 20% of the wireway's interior cross-sectional area »*376.22(A)* and *378.22*«.

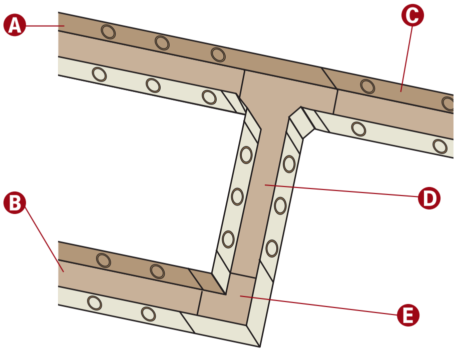
C No conductor larger than that for which the wireway is designed shall be installed »*376.21* and *378.21*«.

D Within **metal wireways,** the derating factors in 310.15(C)(1) are only applicable where the number of current-carrying conductors, including neutral conductors classified as current-carrying under the provisions of 310.15(E), exceeds 30 at any cross section of the wireway »*376.22(B)*«.

E In nonmetallic wireways, the adjustment factors specified in 310.15(C)(1) shall be applicable to the current-carrying conductors up to and including the 20% fill specified in the first paragraph of 378.22 »*378.22*«.

Warning

Where single conductor cables comprising each phase, neutral, or grounded conductor of an alternating-current circuit are connected in parallel as permitted in 310.10(G), the conductors shall be installed in groups consisting of not more than one conductor per phase, neutral, or grounded conductor to prevent current imbalance in the paralleled conductors due to inductive reactance »*376.20* and *378.20*«.



Note

Conductors for signaling circuits or controller conductors between a motor and its starter (used only for starting duty) are not considered as current-carrying conductors »***376.22(B)* and *378.22***«.

The manufacturer's name (or trademark) on all wireways must remain visible after installation. In addition, the interior cross-sectional area (in square inches) must be marked on all nonmetallic wireways »***376.120* and *378.120***«.

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Wireway Installation

Listed nonmetallic wireways are permitted (1) only for exposed work, except as permitted in 378.10(4); (2) where subject to corrosive environments where identified for the use; and (3) in wet locations where listed for the purpose »*378.10*«.

Nonmetallic wireways shall not be used (1) where subject to physical damage; (2) in any hazardous (classified) location, except as permitted by other articles in the *Code;* (3) where exposed to sunlight unless listed and marked as suitable for the purpose; (4) where subject to ambient temperatures other than those for which nonmetallic wireway is listed; and (5) for conductors whose insulation temperature limitations would exceed those for which the raceway is listed »*378.12*«.

A Accessible splices and taps are permitted within a wireway. At the point of any splice or tap, the conductors must not fill the wireway to more than 75% of its area »*376.56(A)* and *378.56*«.

B Close all dead ends with listed fittings »*376.58* and *378.58*«.

C Where insulated conductors are deflected within a wireway, either at the ends or where conduits, fittings, or other raceways (or cables) enter (or leave) the wireway, or where the direction of the wireway is deflected greater than 30°, Table 312.6(A) dimensions corresponding to one wire per terminal apply »*376.23(A)* and *378.23(A)*«.

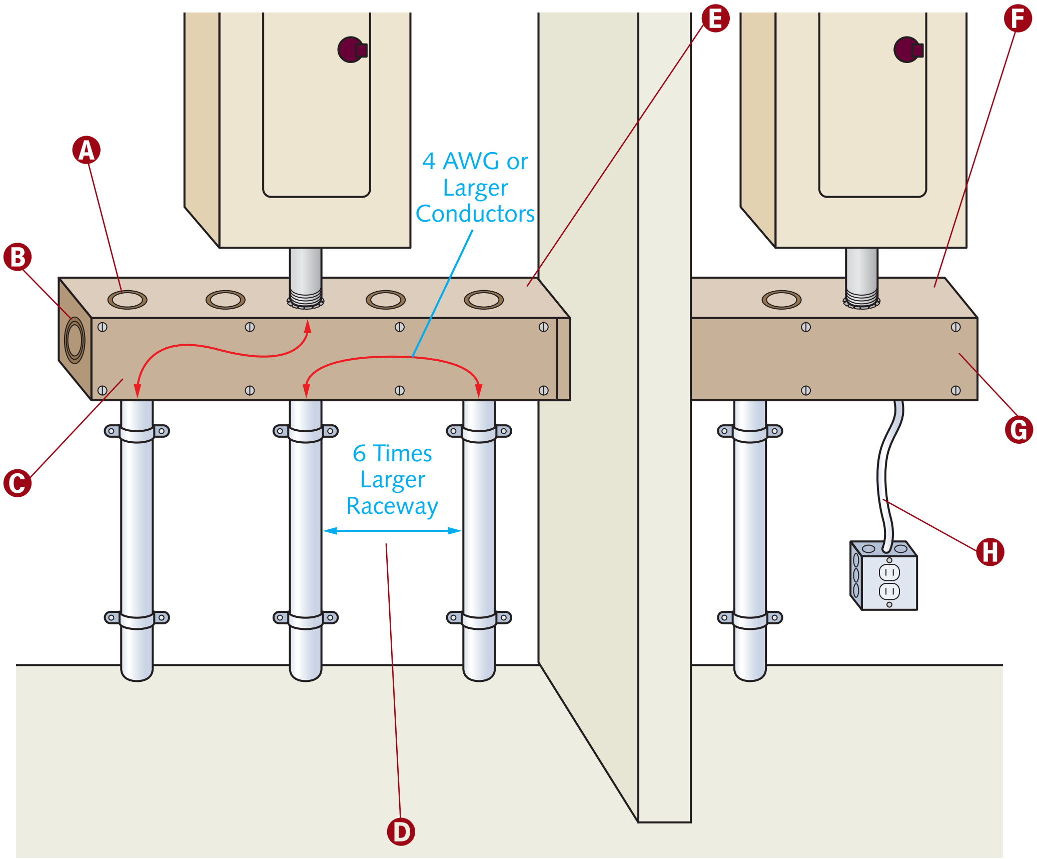
D Where 4 AWG or larger insulated conductors are pulled through a wireway, the distance between raceway and cable entries (enclosing the same conductor) must not be less than that required in 314.28(A)(1) for straight pulls and 314.28(A)(2) for angle pulls »*376.23(B)* and *378.23(B)*«.

E Unbroken wireway lengths can pass transversely through walls. Access to the conductors must be maintained on both sides of the wall »*376.10(4)* and *378.10(4)*«.

F **Metal** wireways can be used (1) for exposed work except as permitted in 376.10(4), or (2) in any hazardous (classified) locations as permitted by other articles in the *NEC* »*376.10*«.

G **Metal** wireways are not permitted where subject to severe physical damage or severe corrosive environments »*376.12*«.

H Extensions from wireways can be made with cord pendants (installed in accordance with 400.14) or with any Chapter 3 wiring method that includes an equipment grounding means. Where a separate equipment grounding conductor is employed, connection of the wiring method's equipment grounding conductors to the wireway must comply with 250.8 and 250.12 »*376.70* and *378.70*«.



Caution

Extreme cold may cause nonmetallic wireways to become brittle and, therefore, more susceptible to damage from physical contact »*378.10(3) Informational Note*«.

Note

Wireways installed in wet locations must be listed for the purpose »***376.10(3)* and *378.10(3)***«.

Note

When transposing cable size into raceway size, the minimum trade size (metric designator) raceway required for the number and size of conductors in the cable shall be used »***376.23(B)* and *378.23(B)***«.

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Power Distribution Blocks in Metal Wireways

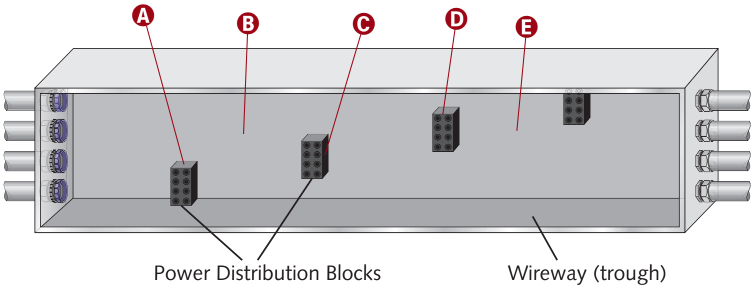
Ⓐ Power distribution blocks installed in metal wireways shall be listed »*376.56(B)(1)*«.

Ⓑ In addition to the wiring space requirement in 376.56(A), the power distribution block shall be installed in a wireway with dimensions not smaller than specified in the installation instructions of the power distribution block »*376.56(B)(2)*«.

Ⓒ Wire bending space at the terminals of power distribution blocks shall comply with 312.6(B) »*376.56(B)(3)*«.

Ⓓ Power distribution blocks shall not have uninsulated live parts exposed within a wireway, whether or not the wireway cover is installed »*376.56(B)(4)*«.

Ⓔ Conductors shall be arranged so the power distribution block terminals are unobstructed following installation »*376.56(B)(5)*«.



Caution

Power distribution blocks installed on the line side of the service equipment shall be marked "suitable for use on the line side of service equipment" or equivalent »*376.56(B)(1)*«.

Note

Requirements for power distribution blocks in boxes are in 314.28(E).

Wireway Supports

Ⓐ Horizontally run metal wireways must be supported at each end »*376.30(A)*«.

Ⓑ The maximum distance between supports for individual lengths of metal wireway must not exceed 10 ft (3 m) »*376.30(A)*«.

Ⓒ Nonmetallic wireway support intervals must not exceed 3 ft (900 mm) »*378.30(A)*«.

Ⓓ Horizontally run individual nonmetallic wireways must be supported at each end or joint »*378.30(A)*«.

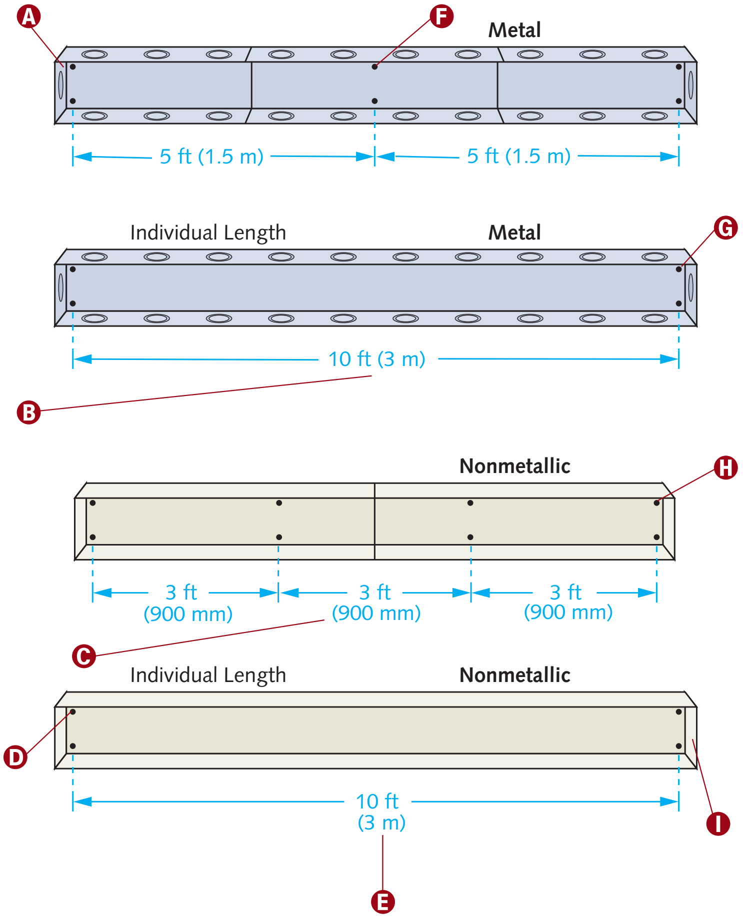
Ⓔ Individual nonmetallic wireways must be supported as listed, and in no case shall the distance between supports exceed 10 ft (3 m) »*378.30(A)*«.

Ⓕ Metal wireway support intervals must not exceed 5 ft (1.5 m) »*376.30(A)*«.

Ⓖ Individual metal wireway lengths (longer than 5 ft [1.5 m]), run horizontally, must be supported at each end or joint, unless listed otherwise »*376.30(A)*«.

Ⓗ Horizontally run nonmetallic wireways must be supported at each end »*378.30(A)*«.

Ⓘ Nonmetallic wireway expansion fittings must be provided to compensate for thermal expansion and contraction where the change in length is expected to be 0.25 in. (6 mm) or more in a straight run »*378.44*«. Expansion characteristics of PVC nonmetallic wireway (which is the same as PVC rigid nonmetallic conduit) are listed in Table 352.44(A).



Note

Nonmetallic wireway vertical runs must be securely supported at intervals of 4 ft (1.2 m) or less (except as otherwise listed) and can have only one joint between supports. Adjoining nonmetallic wireway sections must be securely fastened together to form a rigid joint »*378.30(B)*«.

Metal wireway vertical runs must be securely supported at intervals not exceeding 15 ft (4.5 m) and are limited to one joint between supports. Adjoining wireway sections must be securely fastened together to form a rigid joint »*376.30(B)*«.

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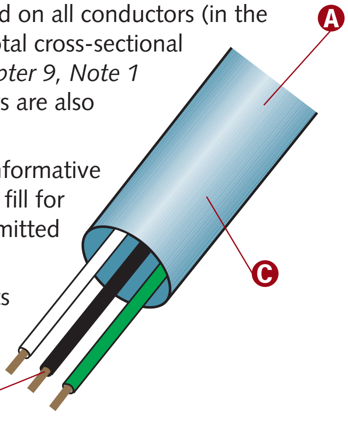
Raceway Fill

Same Size Conductors

Ⓐ Informative Annex C (located in the back of the *Code* book) can be used to find the maximum number of conductors permitted in a particular raceway (conduit or tubing). The conductor maximum is based on all conductors (in the raceway) being the same size (total cross-sectional area including insulation) »*Chapter 9, Note 1 to Tables*«. Compact conductors are also listed in Informative Annex C.

Ⓑ Tables C1 through C13 (in Informative Annex C) are based on the 40% fill for three or more conductors as permitted in Table 1 of Chapter 9.

Ⓒ Informative Annex C also lists the maximum number of fixture wires permitted in each type of conduit (or tubing).



Different Size Conductors

Ⓐ Tables 4, 5, and 5A (of Chapter 9) are used when a combination of different size conductors is installed in a single raceway »*Chapter 9, Note 6 to Tables*«. If the actual values of the conductor diameter and area are known, they shall be permitted to be used »*Chapter 9, Note 10 to Tables*«.

Ⓑ Use the 40% column of Table 4 when there are three or more conductors.

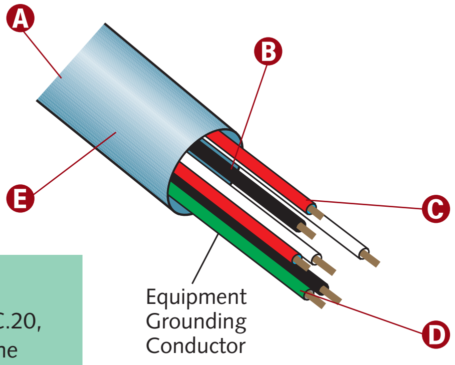
Ⓒ Use Table 5 for dimensions of insulated conductors and Table 5A for dimensions of insulated compact conductors.

Ⓓ Include equipment grounding or bonding conductors, if any, when calculating raceway fill »*Chapter 9, Note 3 to Tables*«.

Ⓔ Table 4 contains trade size information for 13 different types of conduits and tubing. Columns include internal diameters and total area, also referred to as the cross-sectional area. Table 4 also shows the maximum percent fill area for tubing or conduits containing different numbers of conductors.

Note

The approximate area for bare conductors is found in Table 8 of Chapter 9.



Note

Tables C.14 through C.20, in Annex C, provide the maximum number of cables allowed in cable tray.

Raceways Containing Multiconductor Cables

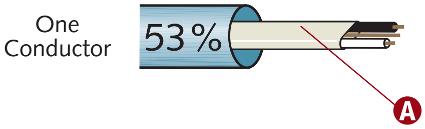
Ⓐ A multiconductor cable, optical fiber cable, or flexible cord of two or more conductors is treated as a single conductor for percentage conduit or tubing fill area calculations. To calculate the cross-sectional area of cables with elliptical cross sections, use the major diameter of the ellipse as a circle diameter »*Chapter 9, Note 9 to Tables*«.

Note

Although Table 1 (in Chapter 9) applies only to complete conduit or tubing systems, it does not apply to sections of conduit used to protect exposed wiring from physical damage »***Chapter 9, Note 2 to Tables***«.

Caution

Assemblies of single insulated conductors without an overall covering shall not be considered a cable when determining conduit or tubing fill area. The conduit or tubing fill for the assemblies shall be calculated based upon the individual conductors »*Chapter 9, Note 9 to Tables*«.

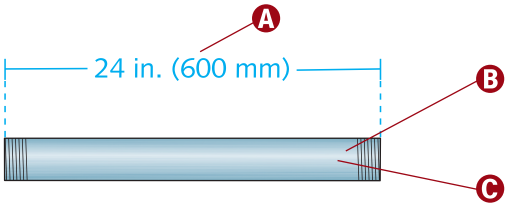


Nipple Fill

Ⓐ A length of conduit (or tubing) measuring 24 in. (600 mm) or less is considered a nipple »*Chapter 9, Note 4 to Tables*«.

Ⓑ For nipples, disregard 310.15(C)(1) adjustment factors »*Chapter 9, Note 4 to Tables*«.

Ⓒ Installed between boxes, cabinets, and similar enclosures, conduit or tubing nipples can be filled to 60% of their total cross-sectional area. The length added by connectors does not count »*Chapter 9, Note 4 to Tables*«.



Note

When calculating the maximum number of same size (total cross-sectional area including insulation) conductors or cables permitted in a conduit or tubing, the next-higher whole number is used when the calculation results in a decimal of 0.8 or larger »***Chapter 9, Note 7 to Tables***«.

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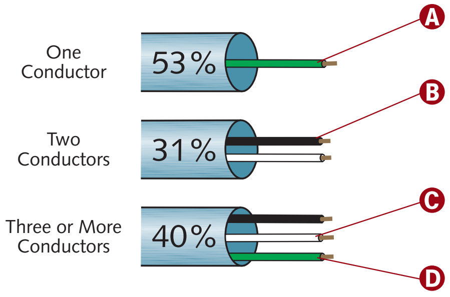
Raceway Fill Percentage

A A conduit having a single conductor or cable can be filled to 53% of the conduit's cross-sectional area.

B A conduit containing exactly two conductors and/or cables can only be filled to 31% of the cross-sectional area of the conduit or tubing.

C A conduit containing three or more conductors and/or cables can be filled to 40% of its cross-sectional area.

D When pulling three conductors or cables into a raceway, if the ratio of the raceway (inside diameter) to the conductor or cable (outside diameter) is between 2.8 and 3.2, jamming can occur. Jamming is less likely to occur when pulling four or more conductors or cables into a raceway »*Chapter 9, Table 1, Informational Note No. 2*«.



Note

Tables 1 and 4 (in Chapter 9) list maximum fill percentages for conduits and tubing.

Caution

Table 1 is based on common conditions of proper cabling and alignment of conductors where the length of the pull and the number of bends are within reasonable limits. Be advised that a larger size conduit (or fewer conductors) should be considered for certain conditions »*Chapter 9, Table 1, Informational Note No.1*«.

Note

To perform the calculation ratio of the raceway to the conductor or cable, divide the total (100%) cross-sectional area of the conduit or tubing by the approximate area of the three conductors and/or cables.

For example, three 3 AWG THHN conductors will be installed in a 1-inch EMT raceway. Find the ratio of the raceway to the conductors.

The total cross-sectional area of 1-inch EMT is 0.864 in.^{2}.

The approximate area for three 3 AWG THHN conductors is 0.2919 in.^{2} ($0.0973 \times 3 = 0.2919$).

The ratio of the raceway to the conductors is 2.96 ($0.864 \div 0.2919 = 2.9599 = 2.96$).

Because 2.96 is between 2.8 and 3.2, there is a higher probability that jamming will occur.

Conductors

Conductors in Parallel

A Conductors of one phase, polarity, neutral, grounded-circuit conductors, or equipment grounding conductors can have different physical characteristics from those of another phase, neutral, grounded-circuit conductors, or equipment grounding conductors and still achieve balance. For example, neutral conductors do not have to be the same length as Phase A conductors, and Phase A conductors do not have to be the same length as Phase B conductors, etc. »*310.10(G)(3)*«.

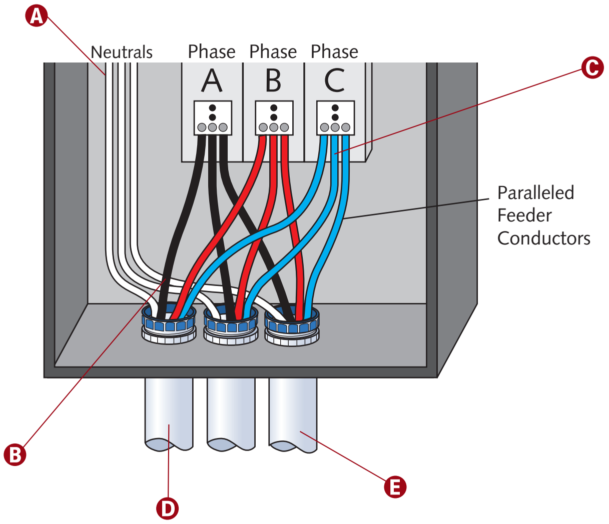
B As a general rule, 1/0 AWG and larger size conductors can be connected in parallel (electrically joined at both ends to form a single conductor) »*310.10(G)(1)*«.

C The paralleled conductors in each phase, polarity, neutral, grounded-circuit conductor, equipment grounding conductors, or equipment bonding jumper must have the same characteristics »*310.10(G)(2)*«. For example, all paralleled, Phase C conductors must:

(1) be the same length,
(2) consist of the same conductor material,
(3) be the same size in circular mil area,
(4) have the same insulation type, and
(5) be terminated in the same manner.

D Conductors carrying alternating current, installed in ferrous metal enclosures or ferrous metal raceways, must be so arranged as to avoid heating the surrounding metal by induction »*300.20(A)*«.

E If run in separate raceways (or cables), the raceways (or cables) must have the same physical characteristics. Where conductors are in separate raceways or cables, the same number of conductors must be used in each raceway or cable »*310.10(G)(3)*«.



Warning

Each ferrous metal raceway (housing paralleled conductors) must contain all phase conductors, the grounded conductor (where used), and all equipment grounding conductors »*300.20(A)*«. For example, a Phase A conductor, a Phase B conductor, a Phase C conductor, and, if used, a neutral (or grounded) conductor and an equipment grounding conductor must be in each raceway.

Note

Equipment grounding conductors used with conductors in parallel must comply with 310.10(G) requirements, applying the sizing requirements of 250.122(F).

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Caution

In wireways, where single conductor cables comprising each phase, neutral, or grounded conductor of an alternating-current circuit are connected in parallel as permitted in 310.10(G), the conductors shall be installed in groups consisting of not more than one conductor per phase, neutral, or grounded conductor to prevent current imbalance in the paralleled conductors due to inductive reactance »*376.20* and *378.20*«.

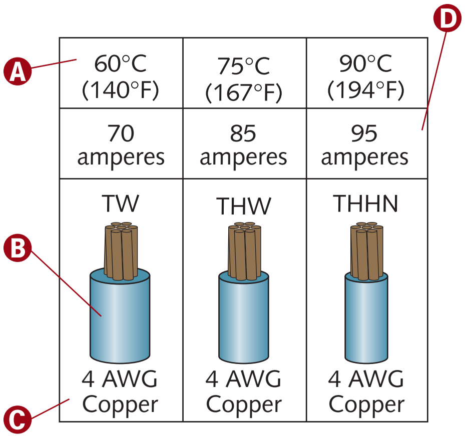
Maximum Ampacities

Ⓐ Ampacities for conductors rated 0 to 2000 volts are specified in the Allowable Ampacity Table 310.16 through Table 310.21, as modified by 310.15(A) through (F) and 310.12 »*310.15(A)*«.

Ⓑ Table 310.4(1) contains specific conductor information, such as trade name, type letter, maximum operating temperature, application provisions, insulation, size, and outer covering.

Ⓒ Tables 310.16 through 310.21 list aluminum (or copper-clad aluminum) as well as copper conductors.

Ⓓ Maximum ampacities are listed in Tables 310.16 through 310.21. Other factors must be considered before using these ampacities: temperature limitations »*110.14(C)*«, continuous loads »*210.19(A)* and *215.2(A)*«, ambient temperature »*Tables 310.15(B)(1)(1)* and *(2)*«, and the number of current-carrying conductors »*310.15(C)(1)*«, to name a few.



Conductor Temperature Limitations—100 Amperes or Less

Ⓐ Equipment termination provisions for circuits rated 100 amperes or less or marked for 14 AWG through 1 AWG conductors are used only for conductors rated 60°C (140°F) »*110.14(C)(1)(a)*«. Because the lowest temperature (weakest link) is 60°C (140°F), the ampacity of this conductor shall not exceed 70 amperes.

Ⓑ A 4 AWG copper conductor with a temperature rating of 60°C (140°F) has an ampacity of 70 amperes »*Table 310.16*«.

Ⓒ A temperature rating of 60/75°C means that the termination is suitable for 60°C (140°F) or 75°C (167°F) conductors.

Ⓓ Conductor temperature limitations can be compared to the strength of a chain. A chain is only as strong as its weakest link. One potential weak link for conductors is the termination (connection) point. The conductor ampacity shall not be higher than the lowest temperature rating of any connected termination, conductor, or device »*110.14(C)*«.

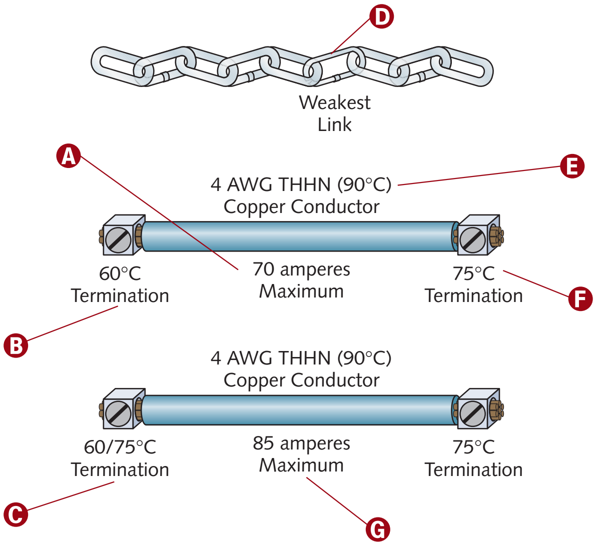
Ⓔ The ampacity of a 4 AWG THHN copper conductor is 95 amperes »*Table 310.16*«.

Ⓕ A 4 AWG copper conductor with a temperature rating of 75°C (167°F) has an ampacity of 85 amperes »*Table 310.16*«.

Ⓖ Equipment termination provisions for circuits rated 100 amperes or less or marked for 14 AWG through 1 AWG conductors can be used for conductors up to their maximum ampacities if the equipment is listed and identified for use with such conductors »*110.14(C)(1)(a)(3)*«. The ampacity of this conductor now has a rating of 85 amperes because the lowest temperature (weakest link) is 75°C (167°F).

Note

When using conductors with temperature ratings higher than those specified for terminations, the higher ampacity can be used for ampacity adjustment, correction, or both »***110.14(C)***«. For example, an adjustment factor of 80% must be applied to 4 AWG THHN copper conductors because there will be four current-carrying conductors in the raceway. The connected load requires an overcurrent protection and conductor ampacity rating of at least 70 amperes, but the lowest temperature rated termination is 60°C. A 70-ampere overcurrent protective device can be installed with 4 AWG THHN (90°C) copper conductors because the allowable ampacity (after the adjustment factor has been applied) is 76 amperes (95 × 80% = 76 amperes). If using the higher ampacity before derating were not permissible, the maximum conductor ampacity would be 56 amperes (70 × 80% = 56 amperes).



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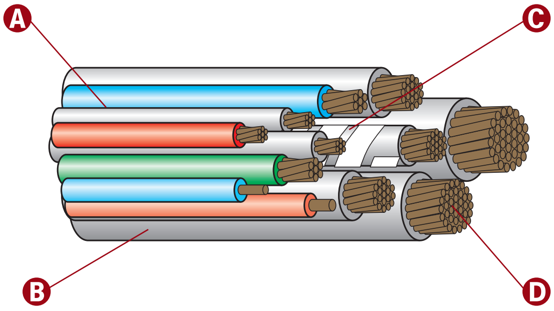
Conductor Properties

A A 6 AWG or smaller insulated grounded conductor must be identified by a continuous white or gray outer finish or by three continuous white stripes on other than green insulation along the conductor's entire length »*200.6(A)*«.

B Table 310.4(1) lists conductor insulations and applications.

C An insulated grounded conductor larger than 6 AWG shall be identified by either a continuous white or gray outer finish or by three continuous white or gray stripes on other than green insulation along the conductor's entire length or, at the time of installation, by a distinctive white or gray marking at its terminations. This marking must encircle the conductor or insulation »*200.6(B)*«.

D Ampacities of insulated conductors rated 0 through 2000 volts, 60°C through 90°C (140°F through 194°F), with three or fewer current-carrying conductors installed in raceway, cable, or earth (directly buried) are found in Table 310.16. The ampacities listed there are based on an ambient temperature of 30°C (86°F). A variety of insulations are listed for both copper and aluminum (or copper-clad aluminum) conductors.



Note

Where installed in raceways, conductors 8 AWG and larger, not specifically permitted or required elsewhere in the *NEC* to be solid, shall be stranded »***310.3(C)***«.

Conductor Temperature Limitations—Over 100 Amperes

Equipment termination provisions for circuits rated over 100 amperes or marked for conductors larger than 1 AWG are used only for conductors with higher temperature ratings provided the conductor ampacity is based on the 75°C (167°F) ampacity of the conductor size used »*110.14(C)(1)(b)*«.

Note

In supervised industrial installations where the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects shall be equal to or greater than 95% of the rating of the overcurrent device specified in 240.6 in accordance with: (1) the conductors are protected within recognized time vs. current limits for short-circuit currents and (2) all equipment in which the conductors terminate is listed and marked for the application »***240.91(B)***«.

Caution

Three paralleled sets of 500 kcmil THHN copper conductors do not meet *NEC* provisions if the overcurrent device is 1200 amperes, unless the equipment is listed and identified for use with 90°C (194°F) conductors. Because of 110.14(C)(1)(b), the maximum ampacity (at 75°C [167°F]) for these conductors is only 380 amperes. The total combined ampacity for each phase is, therefore, only 1140 amperes; Section 240.4(C) requires a minimum conductor ampacity of 1200 amperes.

Note

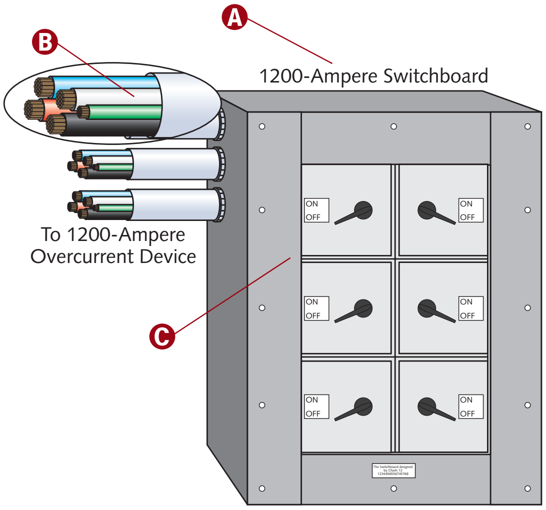
The minimum size conductors (aluminum, copper-clad aluminum, or copper) that can be connected in parallel (electrically joined at both ends to form a single conductor) is size 1/0 AWG, unless meeting an exception »***310.10(G)(1)***«.

Where the overcurrent device is rated over 800 amperes, the ampacity of the conductors it protects must be equal to or greater than the overcurrent device rating »*240.4(C)*«.

A Switchboard, switchgear and panelboard provisions are found in Article 408.

B When running *three* sets of paralleled copper conductors (for a 1200-ampere overcurrent device), the minimum size is 600 kcmil, unless the equipment is listed and identified for use with 90°C (194°F) conductors, or unless meeting the provision in 240.91(B).

C When running *four* sets of paralleled copper conductors (for a 1200-ampere overcurrent device), the minimum size is 350 kcmil, unless the equipment is listed and identified for use with 90°C (194°F) conductors.



All terminations in this switchboard are rated 75°C.

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Ampacity Correction and Adjustment Factors

Where conductors of different systems, as provided in 300.3, are installed in a common raceway or cable, the adjustment factors shown in Table 310.15(C)(1) shall apply only to the number of power and lighting conductors (Articles 210, 215, 220, and 230) »*310.15(C)(1)*«.

The following are not counted as current-carrying conductors when using Table 310.15(C)(1):

- Conductors in cable trays, unless required by 392.80 »*310.15(C)(1)(a)*«.
- Conductors in a raceway having a length not exceeding 24 in. (600 mm) »*310.15(C)(1)(b)*«.
- Adjustment factors shall not apply to underground conductors entering or leaving an outdoor trench if those conductors have physical protection in the form of rigid metal conduit (RMC), intermediate metal conduit (IMC), rigid polyvinyl chloride conduit (PVC), or reinforced thermosetting resin conduit (RTRC) having a length not exceeding 10 ft (3.05 m), and if the number of conductors does not exceed four »*310.15(C)(1)(c)*«.
- Neutral conductors of normally balanced circuits containing three or more conductors »*310.15(E)(1)*«.
- Grounding and bonding conductors »*310.15(F)*«.

The following shall be counted as current-carrying conductors when using Table 310.15(C)(1):

- The neutral conductor in a 3-wire circuit consisting of two phase (hot) wires and the neutral that is fed from a 4-wire, 3-phase wye-connected system »*310.15(E)(2)*«.
- The neutral conductor of a 4-wire, 3-phase wye circuit where the major portion of the load consists of **nonlinear loads,** because harmonic currents are present in the neutral conductor »*310.15(E)(3)*«. Examples: Electronic equipment (such as computers), electronic/electric-discharge lighting (such as fluorescent lights and lights with ballast), adjustable-speed drive systems, and similar equipment »*Informational Note under Nonlinear Load in Article 100*«.
- A grounded conductor of any 2-wire circuit.

Ⓐ When there are more than three current-carrying conductors in a raceway or cable, the allowable ampacity of each conductor must be reduced (derated) as shown in Table 310.15(C)(1) »*310.15(C)(1)*«.

Ⓑ Ambient temperature is the temperature of the conductor's surrounding environment. It is the temperature of the environment in which the conductor, raceway, or cable is installed. This environment may include air, water, earth, or a combination of those elements.

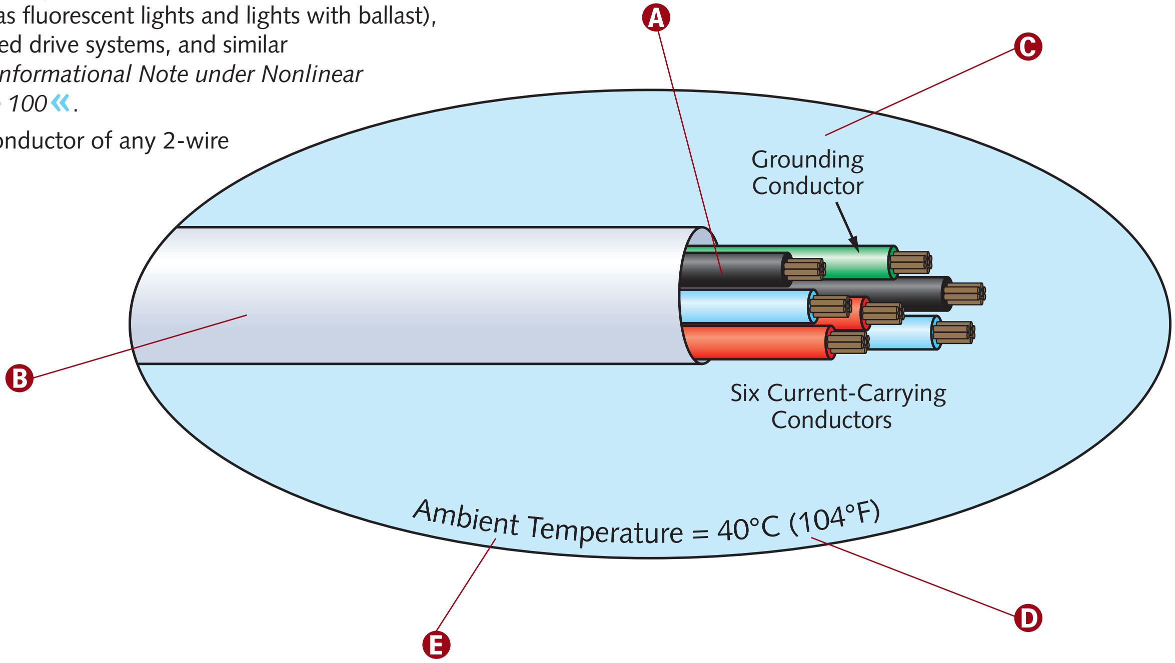
Ⓒ A grounding (or bonding) conductor does not count as a current-carrying conductor »*310.15(F)*«.

Ⓓ When the ambient temperature exceeds 30°C (86°F), the table ampacity has to be multiplied by the ambient temperature correction factor in either Table 310.15(B)(1)(1) or Table 310.15(B)(1)(2).

Ⓔ Ampacity correction factors for ambient temperatures are found in Tables 310.15(B)(1)(1) or (2). These tables are used to correct the ampacity of conductors by multiplying the ampacity of the conductor by the appropriate factor.

Note

The maximum ampacities given in Table 310.16 are based on a maximum of three current-carrying conductors and an ambient temperature of 30°C (86°F). When the ambient temperature is something other than 30°C (86°F), the ampacity of the conductor shall be corrected. While ampacities in Tables 310.16 and 17 are based on an ambient temperature of 30°C (86°F), ampacities in Tables 310.18 through 21 are based on an ambient temperature of 40°C (104°F).


A
C
Grounding Conductor
B
Six Current-Carrying Conductors
Ambient Temperature = 40°C (104°F)
E
D

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Adjustment Factors for Type AC Cable and Type MC Cable

A The adjustment factors in 310.15(C)(1) shall not apply to Type AC cable or to Type MC cable under the following conditions:

a. The cables do not have an overall outer jacket.

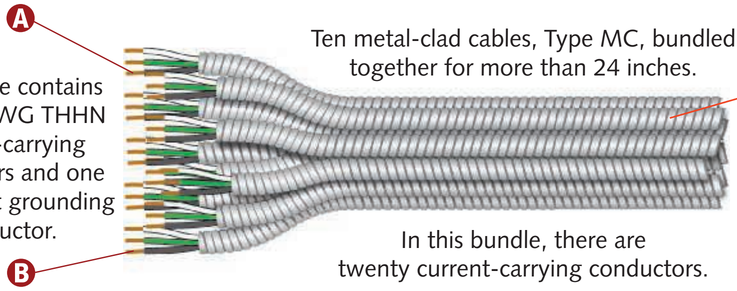
b. Each cable has not more than three current-carrying conductors.

c. The conductors are 12 AWG copper.

d. Not more than 20 current-carrying conductors are installed without maintaining spacing, are stacked, or are supported on "bridle rings" »*310.15(C)(1)(d)*«.

B Normally, Table 310.15(C)(1) adjustment factors apply to cables bundled together, without maintaining spacing, for a continuous length longer than 24 in. (600 mm). But, it will **not** be necessary to apply the adjustment factors to Type AC and Type MC cables meeting the conditions in 310.15(C)(1)(d).

C If cables meeting the requirements in 310.15(C)(1)(d) (1) through (3) with more than 20 current-carrying conductors are installed for longer than 24 in. (600 mm) without maintaining spacing, are stacked, or are supported on bridle rings, a 60% adjustment factor shall be applied »*Exception to 310.15(C)(1)(d)(4)*«.

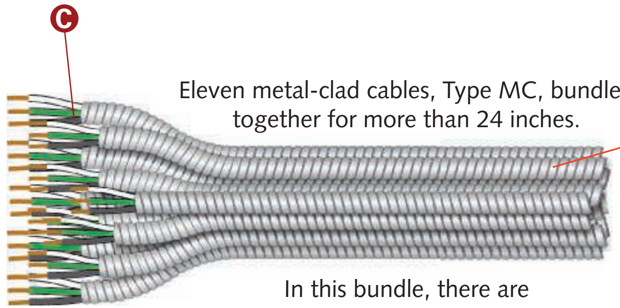


Each cable contains two 12 AWG THHN current-carrying conductors and one equipment grounding conductor.

Ten metal-clad cables, Type MC, bundled together for more than 24 inches.

No overall outer jacket

In this bundle, there are twenty current-carrying conductors.



Six cable contain two 12 AWG THHN current-carrying conductors and five cables contain two 10 AWG THHN current-carrying conductors. Each cable contains an equipment grounding conductor.

Eleven metal-clad cables, Type MC, bundled together for more than 24 inches.

No overall outer jacket

In this bundle, there are twenty-two current-carrying conductors.

Raceways and Cables Exposed to Sunlight on Rooftops

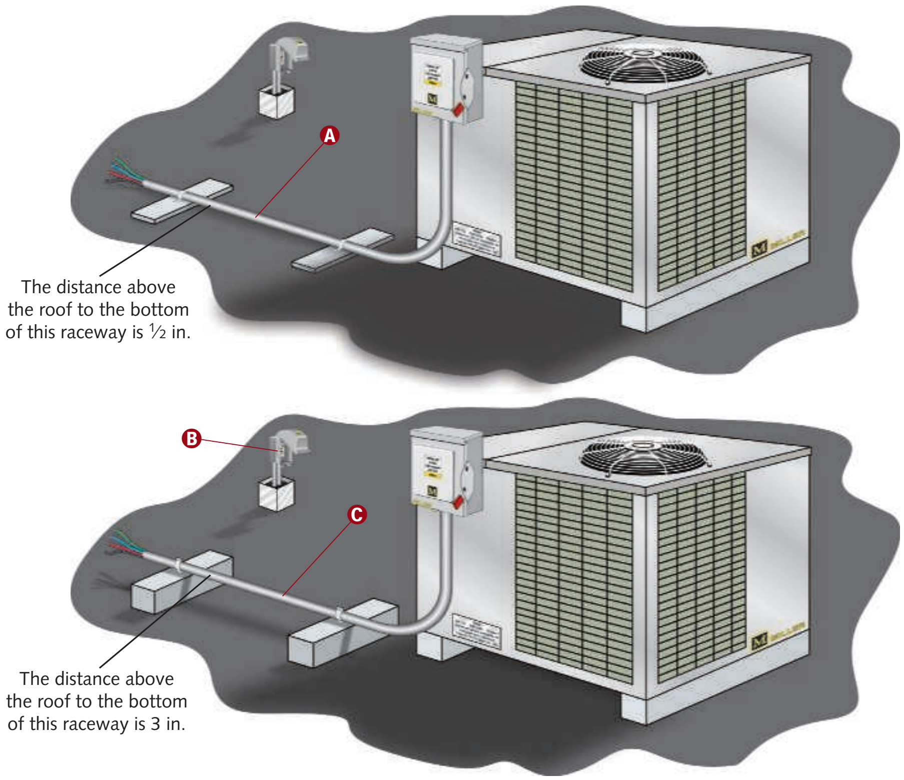
Where raceways or cables are exposed to direct sunlight on or above rooftops, raceways or cables shall be installed a minimum distance above the roof to the bottom of the raceway or cable of ¾ in. (19 mm) »*310.15(B)(2)*«.

Where the distance above the roof to the bottom of the raceway is less than ¾ in. (19 mm), a temperature adder of 33°C (60°F) shall be added to the outdoor temperature to determine the applicable ambient temperature for application of the correction factors in Table 310.15(B)(1)(1) or Table 310.15(B)(1)(2) »*310.15(B)(2)*«.

A Because the distance above the roof to the bottom of this raceway is less than ¾ in. (19 mm) a temperature adder of 33°C (60°F) shall be added to the outdoor temperature to determine the applicable ambient temperature for application of the correction factors in Table 310.15(B)(1)(1) or Table 310.15(B)(1)(2).

B Weather-resistant type, ground-fault circuit-interrupter (GFCI) receptacle with a, outlet box hood listed and identified as "extra duty." [See 210.8(B)(5); and 406.9(B)(1)]

C Because the distance above the roof to the bottom of the raceway is more than ¾ in. no temperature adder is required.


A
The distance above the roof to the bottom of this raceway is ½ in.
B
C
The distance above the roof to the bottom of this raceway is 3 in.

Note

One source for the ambient temperatures in various locations is the ASHRAE Handbook—Fundamentals ***»310.15(B)(2) Informational Note«***.

Example 1: A raceway containing 2 AWG THWN-2 copper conductors is exposed to sunlight on a rooftop. The bottom of the raceway is ½ in. above the roof. The ambient temperature will be 110°F.

The Table 310.16 ampacity (in the 90°C column) is 130 amperes.

Because the distance above the roof to the bottom of this raceway is less than ¾ in., a temperature adder of 60°F is required.

Because of the temperature adder, the ambient temperature is 170°F (110 + 60 = 170).

The Table 310.15(B)(1)(1) correction factor for 170°F (in the 90°C column) is 0.41.

After correcting the ampacity, the maximum ampacity for these 2 AWG THWN-2 conductors is only 53 amperes (130 × 0.41 = 53.3 = 53).

Note

Type XHHW-2 insulated conductors shall not be subject to this ampacity adjustment for raceways and cables exposed to sunlight on rooftops ***»310.15(B)(2) Exception«***.

Example 2: A raceway containing 2 AWG XHHW-2 copper conductors is exposed to sunlight on a rooftop. The bottom of the raceway is ½ in. above the roof. The ambient temperature will be 110°F.

The Table 310.16 ampacity (in the 90°C column) is 130 amperes.

In accordance with the exception to 310.15(B)(2), Type XHHW-2 insulated conductors shall not be subject to this ampacity adjustment for raceways and cables exposed to sunlight on rooftops. Therefore, there is no temperature adder.

The ambient temperature is 110°F.

The Table 310.15(B)(1)(1) correction factor for 110°F (in the 90°C column) is 0.87.

After correcting the ampacity, the maximum ampacity for these 2 AWG XHHW-2 conductors is 113 amperes (130 × 0.87 =113.1 = 113).

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Continuous Loads

Ungrounded (hot) conductors must independently meet requirements for (1) termination and (2) correction and adjustment factors throughout the raceway. (See 210.19(A)(1) for branch-circuit conductors, 215.2(A)(1) for feeder conductors, and 230.42(A)(1) for service conductors.)

Because of the overcurrent device termination [110.14(C)], apply the continuous load correction factor in 210.19(A)(1), using 75°C ampacity column in Table 310.16:

25 ÷ 125% = 20 amperes

In a separate calculation, apply Table 310.15(C)(1) adjustment factors and Table 310.15(B)(1)(1) correction factors, using 90°C ampacity column in Table 310.16:

30 × 0.80 × 0.87 = 20.88 = 21 amperes

Although these conductors have an allowable ampacity of 21 amperes after adjustment and correction factors, the overcurrent device limits the maximum ampacity to 16 amperes.

In accordance with 210.20(A), the maximum on a 20-ampere circuit breaker is 16 amperes:

20 ÷ 125% = 16 amperes

A The maximum continuous load current permitted on a 20-ampere overcurrent device is 16 amperes (20 ÷ 125% = 16).

B A continuous load is expected to maintain maximum current for three hours or more »*Article 100—Definitions*«. Fluorescent office lighting represents a continuous load.

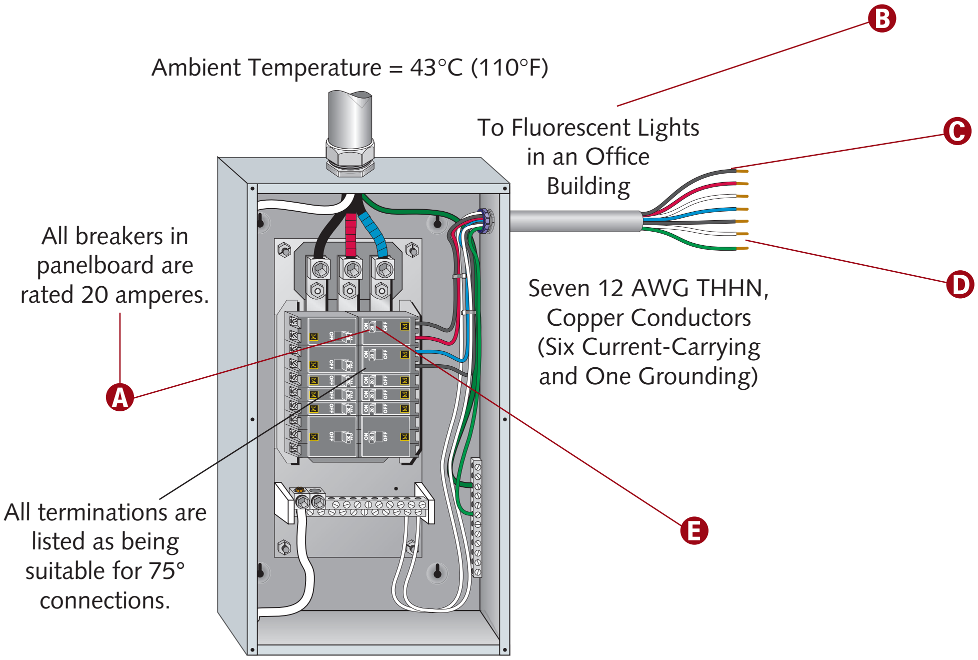
C Branch-circuit conductors shall have an ampacity not less than the larger of the following and comply with 110.14(C) for equipment terminations:

(a) Where a branch circuit supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum branch-circuit conductor size shall have an allowable ampacity not less than the noncontinuous load plus 125% of the continuous load in accordance with 310.14.

(b) The minimum branch-circuit conductor size shall have an allowable ampacity not less than the maximum load to be served after the application of any adjustment or correction factors »*210.19(A)(1)*«.

D Where a branch circuit (or feeder) supplies any combination of continuous and noncontinuous loads, the rating of the overcurrent device shall not be less than the total of the noncontinuous load plus 125% of the continuous load »*210.20(A)* and *215.3*«.

E After conductor adjustment and correction factors have been applied, overcurrent protection can be determined. Where the adjusted ampacity does not correspond to a standard size fuse or circuit breaker, the next higher standard size can be used only (1) if it does not exceed 800 amperes; (2) the conductors being protected are not part of a branch circuit supplying more than one receptacle for cord-and plug-connected portable loads; and (3) the conductor's ampacity does not correspond with the standard ampere rating of a fuse or circuit breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments) »*240.4(B)*«.


Ambient Temperature = 43°C (110°F)
B
To Fluorescent Lights in an Office Building
C
All breakers in panelboard are rated 20 amperes.
D
Seven 12 AWG THHN, Copper Conductors (Six Current-Carrying and One Grounding)
A
E
All terminations are listed as being suitable for 75° connections.

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Support Requirements for Conductors in Vertical Raceways

Ⓐ Conductors in vertical raceways must be supported if the vertical rise exceeds Table 300.19(A) values »*300.19(A)*«. Although three specific methods for supporting cables are listed in 300.19(C)(1), (2), and (3), other equally effective methods are also permitted.

Ⓑ Clamping devices constructed of or employing insulating wedges inserted in raceway ends are one type of conductor support. If clamping the insulation does not adequately support the cable, the conductor must also be clamped »*300.19(C)(1)*«.

Ⓒ At least one support method shall be provided for each conductor at the top of the vertical raceway or as close to the top as practical. Intermediate supports must be provided so that supported conductor lengths do not exceed those specified in Table 300.19(A) »*300.19(A)*«.

Ⓓ Covered boxes can be inserted at the required intervals in which insulating supports are installed and secured in an approved manner to withstand the weight of the conductors attached to them »*300.19(C)(2)*«.

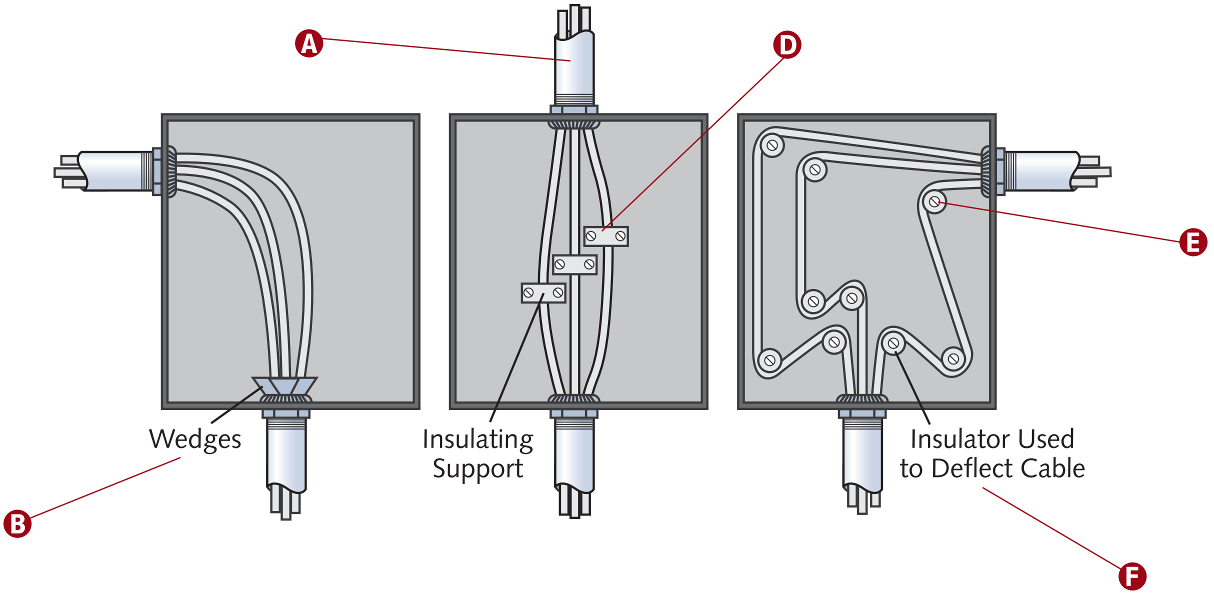
Ⓔ Cables can be supported in junction boxes, by deflecting the cables at least 90° and carrying them horizontally to a distance not less than twice the diameter of the cable, provided the cables are carried on at least two insulating supports and are secured to them by tie wires (if desired) »*300.19(C)(3)*«.

Ⓕ In using an insulator to deflect cable, cables must be supported at intervals not greater than 20% of the values in Table 300.19(A) »*300.19(C)(3)*«.

Table 300.19(A) Maximum Distance between Conductor Supports in Vertical Raceways (in ft)

AWG or Circular-Mil Size of Conductor	*Aluminum or Copper-Clad Aluminum*	*Copper*
18 AWG through 8 AWG	100	100
6 AWG through 1/0 AWG	200	100
2/0 AWG through 4/0 AWG	180	80
250 through 350 kcmil	135	60
400 through 500 kcmil	120	50
600 through 750 kcmil	95	40
Over 750 kcmil	85	35

Ⓒ



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Summary

- Raceways shall not be supported by ceiling grid support wires, but can be supported by independent (additional) support wires.
- Raceways shall not support other raceways, cables, conductors, or nonelectric equipment.
- The maximum total of conduit bends, between pull points, is four quarter bends (360°).
- RMC is a heavy-walled metal raceway that can be threaded.
- IMC has thinner walls than does RMC, and it can also be threaded.
- Unless made up with threaded couplings, RMC and IMC support requirements are the same as EMT.
- EMT, the thinnest-walled classification of metal nonflexible raceways, provides protection from all but severe physical damage.
- The maximum distance between PVC supports increases as conduit size increases.
- Certain raceways, permitted as luminaire whips, do not require support if installed in lengths of 6 ft or less.
- Wireways are troughs with hinged or removable covers for housing and protecting conductors and cables.
- Wireways can pass transversely through walls if the length passing through the wall is unbroken and if conductors can be accessed on both sides of the wall.
- Raceway fill can be calculated from Tables 4 and 5, located in Chapter 9.
- Conduit (and tubing) nipples can be filled to 60% of their cross-sectional area.
- Certain conductor properties are listed in Table 310.4(1).
- Conductor temperature limitations must be considered when determining overcurrent protection.
- Ambient temperature, the number of current-carrying conductors, and continuous loads can alter maximum conductor ampacity or overcurrent protection.

Unit 5 Competency Test

***NEC*® Reference** **Answer**

____________ ____________ 1. Where exposed to the weather, raceways enclosing service-entrance conductors shall be:

a) rainproof and arranged to drain.
b) watertight and arranged to drain.
c) weatherproof and arranged to drain.
d) listed or approved for use in wet locations and arranged to drain.

____________ ____________ 2. Rigid metal conduit shall have a maximum of four ____________ bends between pull points.

____________ ____________ 3. The cross-sectional area of 2-in. EMT is ____________ in.^{2}

____________ ____________ 4. All cut ends of conduits shall be reamed or otherwise finished to remove rough edges. Where rigid metal conduit is threaded in the field, a standard cutting die with a ____________-in. taper per ft (1 in 16) shall be used.

____________ ____________ 5. Multioutlet assemblies shall not:

I. be installed in hoistways.
II. run within dry partitions.
III. run through dry partitions.

a) I only b) III only c) I and II only d) I, II, and III

____________ ____________ 6. Splices and taps shall be permitted within a metal wireway provided they are accessible. The conductors, including splices and taps, shall not fill the wireway to more than ____________ of its area at that point.

NEC® Reference **Answer**

____________ ____________ 7. A ____________ is defined as a transverse raceway for electric conductors, providing access to predetermined cells of a cellular metal floor, thereby permitting the installation of electric conductors from a distribution center to the cells.

____________ ____________ 8. In both exposed and concealed locations, where a cable or raceway-type wiring method is installed through bored holes in joist, rafters, or wood members, holes shall be bored so that the edge of the hole is not less than ____________ in. from the edges of the wood member.

____________ ____________ 9. How many 14 AWG THHN conductors, including an equipment grounding conductor, can be installed in a ⅜-in. flexible metal conduit using fittings inside of the conduit?

____________ ____________ 10. What is the maximum distance (in ft) between supports for a straight run of 2-in. IMC made up with threaded couplings?

____________ ____________ 11. The sum of cross-sectional areas of all contained conductors and cables at any cross section of a nonmetallic wireway shall not exceed ____________ fill.

____________ ____________ 12. Where conductors carrying alternating current are installed in ferrous metal raceways, they shall be so arranged as to avoid heating the surrounding metal by ____________.

____________ ____________ 13. A ____________ is a type of surface, flush, or freestanding assemblage with a raceway and fittings or other enclosure provided with one or more receptacles, for the purpose of supplying power to utilization equipment.

____________ ____________ 14. Where practicable, contact between dissimilar metals anywhere in the system shall be avoided to eliminate the possibility of ____________.

____________ ____________ 15. What is the maximum number of 4 AWG THHN conductors permitted in 1¼-in. rigid metal conduit?

____________ ____________ 16. Where the same 4 AWG conductor enters and then exits a wireway through conduit or tubing, the distance between those raceway entries shall not be less than ____________ times the trade diameter of the largest raceway, when angle or U pulls are made.

____________ ____________ 17. What is the maximum allowable ampacity for a 3 AWG THHN copper conductor where the temperature termination on one end is rated 75°C and the rating of the temperature termination on the other end is unknown? The ambient temperature will not exceed 30°C and there will not be more than three current-carrying conductors in the raceway.

____________ ____________ 18. Where an equipment bonding jumper is installed on the outside of a raceway, the length shall not exceed ____________ ft and shall be routed with the raceway or enclosure.

____________ ____________ 19. Connections from headers to cabinets and other enclosures, in cellular concrete floor raceways, shall be made by means of:

I. listed metal raceways.

II. listed nonmetallic raceways.

III. listed fittings.

a) I only b) I and II only c) I and III only d) I, II, and III

____________ ____________ 20. ENT shall be secured at least every ____________ ft.

____________ ____________ 21. IMC encased in a concrete slab, on the first floor of an office building, is considered to be in a ____________ location.

____________ ____________ 22. When an outlet from an underfloor raceway is discontinued, the sections of circuit conductors supplying the outlet:

a) shall be permitted to be spliced.

b) shall be removed from the raceway.

c) shall be permitted to be reinsulated.

d) shall be handled like abandoned outlets on loop wiring.

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***NEC*® Reference**	**Answer**	
___________	___________	23. RMC, elbows, couplings, and fittings shall be permitted to be installed in concrete, in direct contact with the earth, or in areas subject to severe corrosive influences where protected by ___________ approved for the condition.
___________	___________	24. Where installed in raceways, conductors ___________ and larger, not specifically permitted or required elsewhere in the *NEC* to be solid, shall be stranded.
___________	___________	25. In vertical raceways, 3/0 AWG aluminum conductors must be supported if the vertical rise is greater than ___________ ft.
___________	___________	26. Where raceways contain ___________ or larger insulated circuit conductors, and these conductors enter a cabinet, a box, an enclosure, or a raceway, the conductors shall be protected by an identified fitting providing a smoothly rounded insulating surface, unless the conductors are separated from the fitting or raceway by identified insulating materials that are securely fastened in place.
___________	___________	27. Nonmetallic wireways shall be supported where run horizontally at intervals not to exceed ___________ ft, and at each end or joint, unless listed for other support intervals.
___________	___________	28. Horizontal runs of IMC supported by openings through framing members at intervals not exceeding ___________ ft and securely fastened within ___________ ft of termination points shall be permitted.
___________	___________	29. If a 1¼-in. EMT raceway containing three conductors is already filled to 20%, what is the raceway's cross-sectional area?
___________	___________	30. Expansion fittings and telescoping sections of metal raceways shall be made electrically continuous by ___________ or other means.
___________	___________	31. RMC shall be securely fastened within ___________ ft of each outlet box, junction box, device box, cabinet, conduit body, or other conduit termination.
___________	___________	32. The maximum distance between supports for 4-in. PVC is ___________ ft.
___________	___________	33. When calculating the maximum number of conductors or cables permitted in a conduit or tubing, all of the same size (total cross-sectional area including insulation), the next-higher whole number shall be used to determine the maximum number of conductors permitted when the calculation results in a decimal greater than or equal to ___________.
___________	___________	34. Where insulated conductors are deflected within a metal wireway, either at the ends or where conduits, fittings, or other raceways or cables enter or leave the wireway, or where the direction of the wireway is deflected greater than ___________, dimensions corresponding to one wire per terminal in Table 312.6(A) shall apply.
___________	___________	35. Where the distance above the roof to the bottom of the raceway is less than ¾ in., a temperature adder of ___________°F shall be added to the outdoor temperature to determine the applicable ambient temperature for application of the correction factors in Table 310.15(B)(1)(1) or Table 310.15(B)(1)(2).
___________	___________	36. Conductors in metal wireways shall be arranged so the power distribution block terminals are ___________ following installation.
___________	___________	37. As a general rule, ___________ and larger conductors shall be permitted to be connected in parallel (electrically joined at both ends).

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Section 2

One-Family Dwellings

Unit 6

General Provisions

Objectives

After studying this unit, the student should be able to:

- calculate the minimum number of 15- and 20-ampere branch circuits in a one-family dwelling.
- list the four types of branch circuits (appliance, general-purpose, individual, and multiwire) and explain the differences between them.
- summarize which circuits shall have arc-fault circuit interrupter (AFCI) protection.
- recall the branch-circuit ratings allowed for general-purpose receptacles.
- explain how to lay out general-purpose receptacles in a dwelling.
- list the receptacle ratings allowed on various sizes and types of branch circuits.
- summarize the requirements for receptacle boxes.
- explain split-wire receptacles.
- recall the requirements for wet bar receptacles.
- remember the provisions concerning the minimum length of free conductors inside boxes.
- clarify receptacle replacement requirements.
- summarize the general requirements for lighting and switches.
- recall provisions pertaining to ceiling-suspended (paddle) fans.
- recall general requirements for devices and luminaire boxes.
- explain the provisions for outdoor receptacles.
- summarize the provisions concerning illuminating outdoor entrances and exits.

Introduction

Unit 6 contains provisions concerning general areas both inside and outside of one-family dwellings. A one-family dwelling is a building consisting solely of one dwelling unit »*Article 100*«. Learning codes that pertain to one-family dwellings is of great importance because these codes are the foundation for all residential wiring. One-family dwellings are built in all shapes and sizes. Some general codes apply to every dwelling, such as the placement of receptacles in habitable rooms.

Nonmetallic-sheathed cable is the most common wiring type installed in one-family dwellings. Article 334 covers the use, installation, and construction specifications of nonmetallic-sheathed cable (Types NM and NMC). Uses permitted for nonmetallic-sheathed cable are covered in 334.10 and uses not permitted are in 334.12. (See Unit 4 of this text for *Code* requirements pertaining to nonmetallic-sheathed cable.)

Prior to the 2008 edition of the *NEC*®, only 120-volt, single-phase, 15- and 20-ampere branch circuits supplying outlets installed in dwelling unit bedrooms were required to be arc-fault circuit-interrupter protected. Now all 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar rooms or areas shall be protected by any of the means described in 210.12(A)(1) through (6).

Over the last several editions of the *NEC*, requirements for GFCI and AFCI protection have expanded. See 210.8(A) for GFCI protection for personnel requirements and 210.12 for AFCI protection requirements.

Branch Circuits

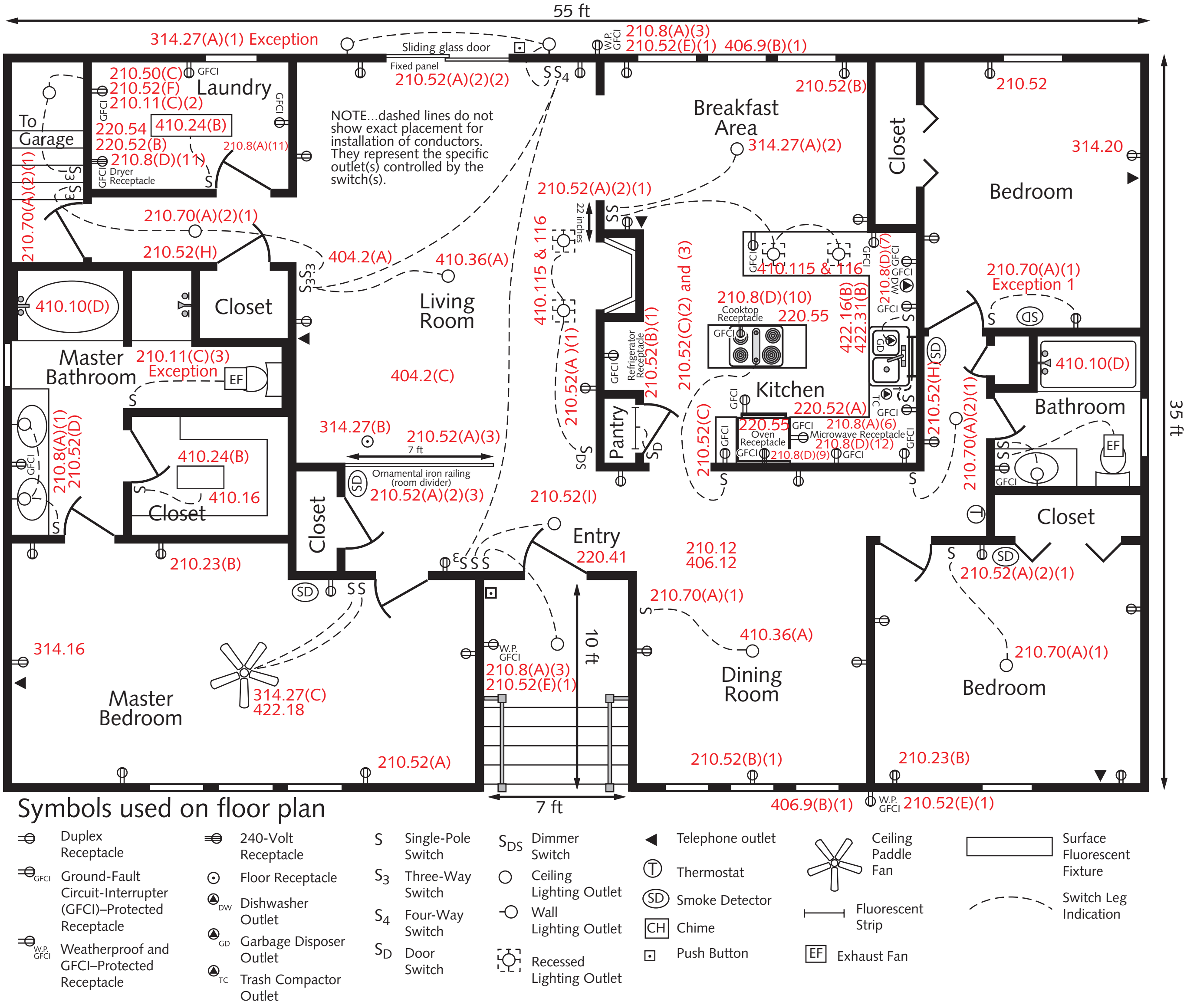
Electrical Floor Plan (Blueprint)

Electrical blueprints (floor plans) may be optional on a one-family dwelling. Sometimes it is the responsibility of the electrician to design and install the electrical system. The accompanying electrical floor plan shows receptacles, lighting, switches, and other items that might be found on a residential plan. The *NEC* references (shown here in red), are, of course, not present on general plans. This blueprint shows many but not all of the *NEC* references that are needed for a code-compliant installation.

This chapter covers everything in a one-family dwelling, from a single receptacle in an individual branch circuit to illumination of entrances and exits. Branch circuits are explained briefly in this unit and in greater detail in later units. Receptacles have both general and specific codes. General codes are explained in this unit, while specific codes for rooms and areas with special receptacle requirements are explained in Unit 7. This unit also includes general requirements for lighting and switches, while specific requirements can be found in Unit 7.

Caution

Some state and local jurisdictions may not allow the use of nonmetallic-sheathed cable in any dwelling. Obtain a copy of any additional rules and regulations for your area.


55 ft
35 ft
314.27(A)(1) Exception
Sliding glass door
Fixed panel
210.52(A)(2)(2)
W.P. GFCI
210.8(A)(3)
210.52(E)(1) 406.9(B)(1)
To Garage
210.50(C)
GFCI
210.52(F)
210.11(C)(2)
Laundry
220.54
410.24(B)
220.52(B)
210.8(A)(11)
210.8(D)(11)
Dryer Receptacle
210.70(A)(2)(1)
210.52(H)
404.2(A)
410.36(A)
Breakfast Area
314.27(A)(2)
210.52(B)
Closet
210.52
314.20
Bedroom
210.52(A)(2)(1)
22 inches
410.115 & 116
210.52(C)(2) and (3)
210.8(D)(7)
DW
GD
TC
210.8(D)(10)
Cooktop Receptacle
220.55
422.16(B)
422.31(B)
Living Room
410.10(D)
Closet
Master Bathroom
210.11(C)(3) Exception
EF
404.2(C)
Refrigerator Receptacle
210.52(B)(1)
210.52(A)(1)
Pantry
Kitchen
220.52(A)
220.55
Oven Receptacle
210.8(A)(6)
Microwave Receptacle
210.8(D)(12)
210.8(D)(9)
210.52(C)
210.52(H)
210.70(A)(2)(1)
210.70(A)(1) Exception 1
SD
410.10(D)
Bathroom
314.27(B)
210.52(A)(3)
7 ft
Ornamental iron railing (room divider)
210.52(A)(2)(3)
210.8(A)(1)
210.52(D)
410.24(B)
410.16
Closet
Closet
210.52(I)
Entry
220.41
210.12
406.12
Closet
210.52(A)(2)(1)
210.23(B)
314.16
210.70(A)(1)
410.36(A)
10 ft
210.8(A)(3)
210.52(E)(1)
Dining Room
210.70(A)(1)
Bedroom
Master Bedroom
314.27(C)
422.18
210.52(A)
210.52(B)(1)
210.23(B)
7 ft
406.9(B)(1)
210.52(E)(1)
Symbols used on floor plan
Duplex Receptacle
GFCI Ground-Fault Circuit-Interrupter (GFCI)–Protected Receptacle
W.P. GFCI Weatherproof and GFCI–Protected Receptacle
240-Volt Receptacle
Floor Receptacle
DW Dishwasher Outlet
GD Garbage Disposer Outlet
TC Trash Compactor Outlet
S Single-Pole Switch
S3 Three-Way Switch
S4 Four-Way Switch
SD Door Switch
SDS Dimmer Switch
Ceiling Lighting Outlet
Wall Lighting Outlet
Recessed Lighting Outlet
Telephone outlet
T Thermostat
SD Smoke Detector
CH Chime
Push Button
Ceiling Paddle Fan
Fluorescent Strip
EF Exhaust Fan
Surface Fluorescent Fixture
Switch Leg Indication

NOTE...dashed lines do not show exact placement for installation of conductors. They represent the specific outlet(s) controlled by the switch(s).

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AFCI Protection

Ⓐ An arc-fault circuit interrupter (AFCI) is a device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected »*Article 100*«.

Ⓑ All 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar rooms or areas shall be protected by any of the means described in 210.12(A)(1) through (6):

(1) A listed combination-type arc-fault circuit interrupter, installed to provide protection of the entire branch circuit

(2) A listed branch/feeder-type AFCI installed at the origin of the branch-circuit in combination with a listed outlet branch-circuit type AFCI installed on the branch circuit at the first outlet box which shall be marked to indicate that it is the first outlet of the branch circuit.

(3) A listed supplemental arc protection circuit breaker installed at the origin of the branch circuit in combination with a listed outlet branch-circuit type AFCI installed on the branch circuit at the first outlet box if all of the following conditions are met:

   a. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit AFCI.

   b. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 50 ft (15.2 m) for a 14 AWG conductor or 70 ft (21.3 m) for a 12 AWG conductor.

   c. The first outlet box shall be marked to indicate that it is the first outlet of the branch circuit.

(4) A listed outlet branch-circuit type AFCI installed on the branch circuit at the first outlet in combination with a listed branch-circuit overcurrent protective device if all of the following conditions are met:

   a. The branch-circuit wiring shall be continuous from the branch-circuit overcurrent device to the outlet branch-circuit AFCI.

   b. The maximum length of the branch-circuit wiring from the branch-circuit overcurrent device to the first outlet shall not exceed 50 ft (15.2 m) for a 14 AWG conductor or 70 ft (21.3 m) for a 12 AWG conductor.

   c. The first outlet box shall be marked to indicate that it is the first outlet of the branch circuit.

   d. The combination of the branch-circuit overcurrent device and outlet branch-circuit AFCI shall be identified as meeting the requirements for a system combination-type AFCI and shall be listed as such.

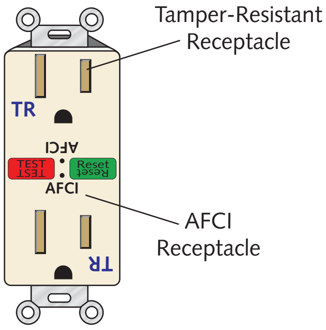
(5) If metal raceway, metal wireways, metal auxiliary gutters, Type MC cable, or Type AC cable meeting the applicable requirements of 250.118, with metal boxes, metal conduit bodies, and metal enclosures are installed for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a listed outlet branch-circuit type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit.

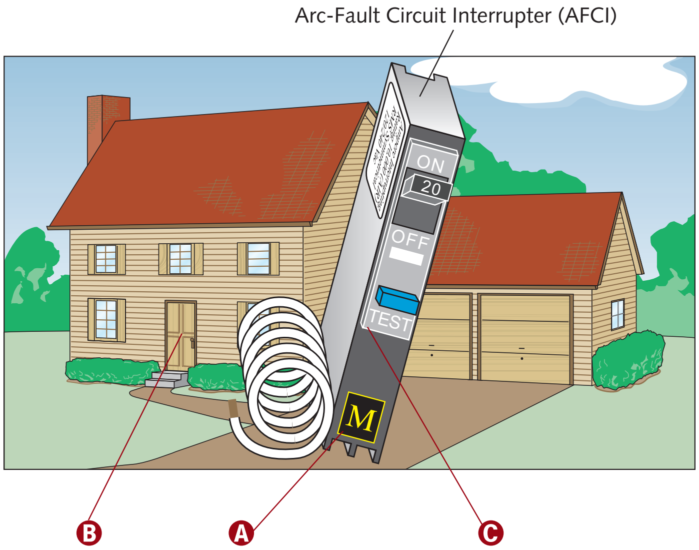
(6) Where a listed metal or nonmetallic conduit or tubing or Type MC cable is encased in not less than 2 in. (50 mm) of concrete for the portion of the branch circuit between the branch-circuit overcurrent device and the first outlet, it shall be permitted to install a listed outlet branch-circuit type AFCI at the first outlet to provide protection for the remaining portion of the branch circuit » *210.12(A)* and *(B)*«.

Ⓒ If branch circuit wiring for any of the areas specified in 210.12(B), (C), or (D) is modified, replaced, or extended, the branch circuit shall be protected by: (1) by any of the means described in 210.12(A)(1) through (A)(6), or (2) a listed outlet branch-circuit-type AFCI located at the first receptacle outlet of the existing branch circuit »*210.12(E)*«.

Note

AFCI protection shall not be required where the extension of the existing conductors is not more than 6 ft (1.8 m) and does not include any additional outlets or devices »***210.12(E) Exception***«.





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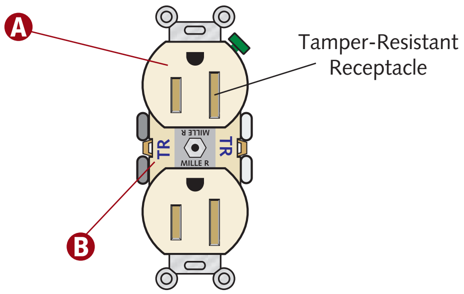
Tamper-Resistant Receptacles in Dwelling Units

Ⓐ All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles in the areas specified in 406.12(1) through (10) shall be listed tamper-resistant receptacles »*406.12*«.

Ⓑ Tamper-resistant receptacles are identified by the letters "TR" or the words "Tamper Resistant." After the receptacle has been installed, the identification is only required to be visible with the cover plate removed. See UL (Underwriter Laboratories) White Book, category: Receptacles for Plugs and Attachment Plugs (RTRT).



Note

It is not required to install tamper-resistant receptacles in the following areas:

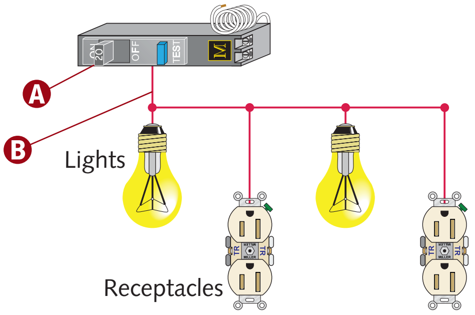
1. Receptacles located more than 5½ ft (1.7 m) above the floor.
2. Receptacles that are part of a luminaire or appliance.
3. Where the receptacle outlet is installed within the space occupied by or designated for each appliance that in normal use is not easily moved from one place to another and is cord-and-plug-connected in accordance with 400.10(A)(6), (A)(7), or (A)(8), the following are permitted:
    a. A single receptacle that is not readily accessible and supplies one appliance
    b. A duplex receptacle that is not readily accessible and supplies two appliances.
4. Nongrounding receptacles used for replacements as permitted in 406.4(D)(2)(a) ***»406.12 Exception«***.

General-Purpose Branch Circuit

A general-purpose branch circuit may feed lights, receptacles, or both.

Ⓐ General-purpose branch-circuit overcurrent protection shall not exceed 15 amperes for 14 AWG copper, 20 amperes for 12 AWG copper, and 30 amperes for 10 AWG copper »*240.4(D)*«.

Ⓑ Branch-circuit conductors shall have an ampacity sufficient for the loads served »*210.19*«.

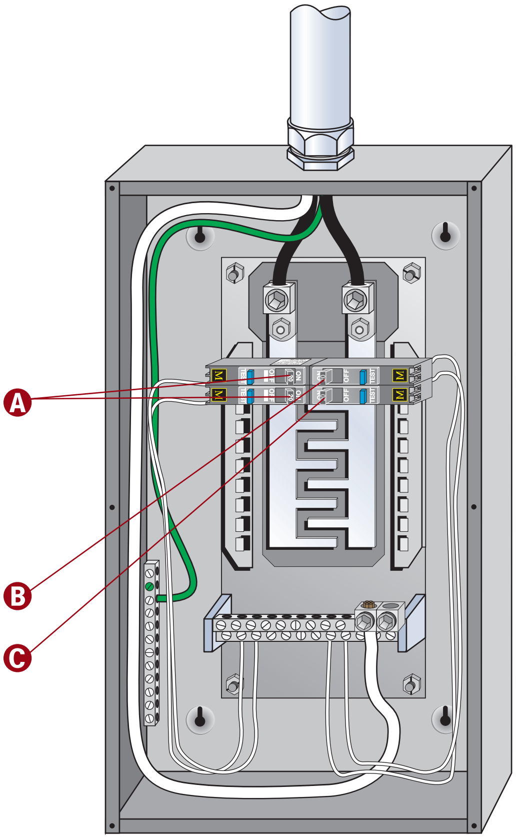


Required Branch Circuits

Ⓐ A minimum of two 20-ampere small appliance branch circuits are required »*210.11(C)(1)*«. See also 210.52(B).

Ⓑ At least one 20-ampere laundry branch circuit is required »*210.11(C)(2)*«. See also 210.52(F).

Ⓒ A minimum of one 120-volt, 20-ampere bathroom branch circuit is required »*210.11(C)(3)*«. See also 210.52(D).



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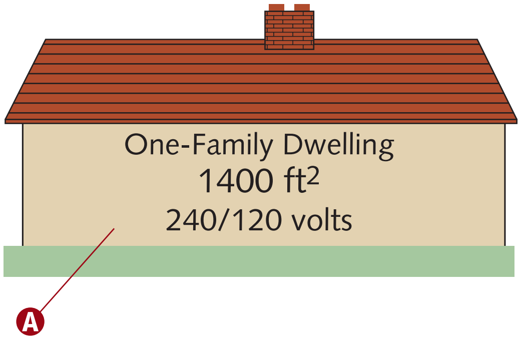
Calculating 15-Ampere Branch Circuits

A Calculation to find the minimum number of 15-ampere branch circuits:

- Calculate the general lighting and receptacle load in accordance with 220.41.
- First, multiply 1400 ft^2 by 3 volt-amperes:

  1400 × 3 = 4200 volt-amperes
- Next, divide the total volt-amperes by 120 volts to find the total amperes:

  4200 ÷ 120 = 35 amperes
- Finally, divide 35 amperes by 15 (for a 15-ampere circuit) to find the minimum number of circuits: 35 ÷ 15 = 2.33. (Round up to the next whole number if the result of the calculation is not a whole number.)
- If 15-ampere circuits are installed for general lighting and receptacles, then at least three circuits are required.

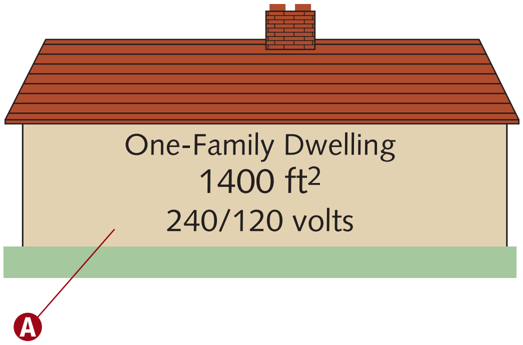


Calculating 20-Ampere Branch Circuits

A Calculation to find the minimum number of 20-ampere branch circuits:

- Calculate the general lighting and receptacle load in accordance with 220.41.
- First, multiply 1400 ft^2 by 3 volt-amperes:

  1400 × 3 = 4200 volt-amperes
- Next, divide the total volt-amperes by 120 volts to find the total amperes: 4200 ÷ 120 = 35 amperes
- Finally, divide 35 amperes by 20 (for a 20-ampere circuit) to find the minimum number of circuits: 35 ÷ 20 = 1.75. (Round up to the next whole number if the result of the calculation is not a whole number.)
- If 20-ampere circuits are installed for general lighting and receptacles, then at least two circuits are required.



Note

At least four 20-ampere branch circuits are required (in addition to any installed for general lighting and receptacles): two small appliance branch circuits, one laundry branch circuit, and one bathroom branch circuit. Dwelling units with attached or detached garages with electric power require at least one additional 20-ampere branch circuit for the receptacle outlets in the garage **»*210.11(C)*«**.

Individual Branch Circuit for a Water Heater

A Calculation to find the maximum overcurrent protective device:

- The overcurrent protection shall not exceed the rating marked on the appliance. If the rating is not marked and the appliance is rated over 13.3 amperes, the overcurrent protection shall not exceed 150% of the rated current »*422.11(E)(3)*«: 18.75 × 150% = 28.13.
- If the calculated rating does not correspond to a standard size fuse or breaker, as found in *240.6(A)*, the next higher standard rating shall be permitted »*422.11(E)(3)*«. The next standard size fuse or breaker higher than the calculated rating of 28.13 amperes is 30 amperes.
- The maximum overcurrent protective device (fuse or breaker) is 30 amperes.

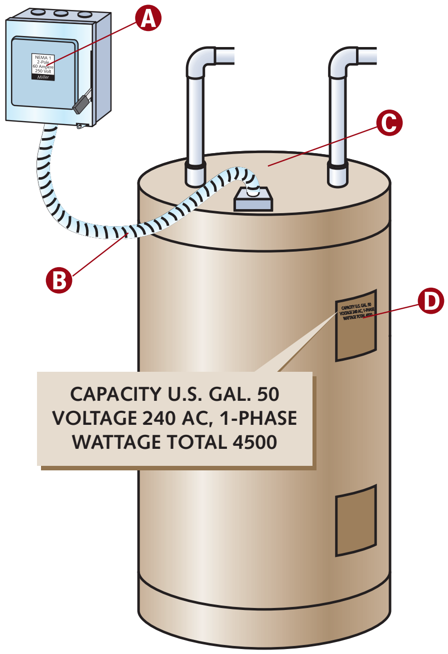
B The minimum conductor size is 10 AWG copper »*Table 310.16*«. Because the overcurrent protection shall not exceed 20 amperes for 12 AWG copper, 12 AWG conductors are not permitted »*240.4(D)*«.

C The branch-circuit overcurrent device and conductors for fixed storage-type water heaters that have a capacity of 120 gal (450 L) or less shall be sized not smaller than 125% of the rating of the water heater »*422.13*«.

D Calculation to find the minimum circuit ampacity:

- First, divide the wattage by the voltage to find amperage:

  4500 ÷ 240 = 18.75
- Next, multiply the amperage by 125% as required by 422.13: 18.75 × 125% = 23.44
- The minimum ampacity required for this water heater is 23.44 amperes.



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Ampere Rating of Receptacles

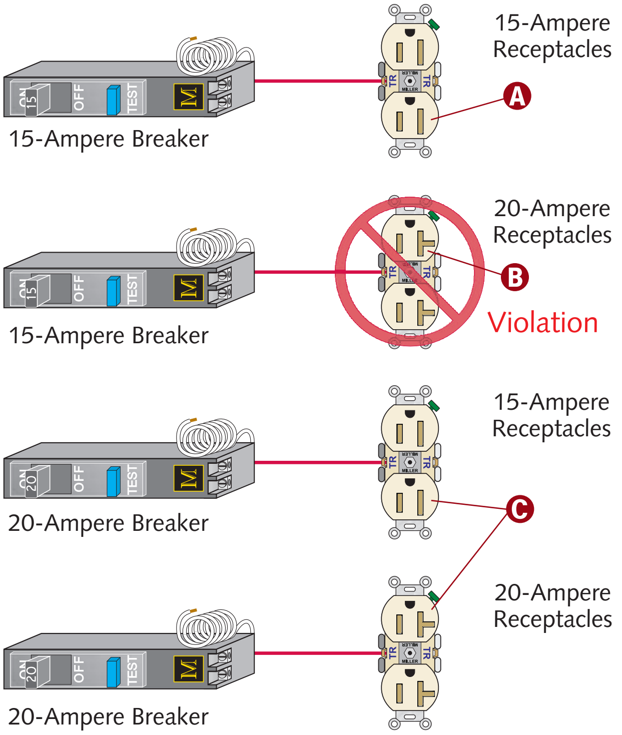
Receptacle branch circuits must have a rating of 20 amperes for laundry areas, bathrooms, garages, kitchens (except for refrigeration equipment supplied from an individual branch circuit rated 15 amperes or greater), dining rooms, pantries, breakfast rooms, and similar areas. Throughout the remainder of a one-family dwelling, 15-ampere receptacle branch circuits are allowed.

Lighting and receptacles can share the same branch circuit, except for small-appliance receptacles, garage receptacles, bathroom receptacles (unless the circuit supplies a single bathroom), and laundry receptacles »*210.23(B)* and *210.11(C)*«. See Unit 7 for additional information concerning receptacles and lighting in these specific areas.

Ⓐ Receptacles installed on 15-ampere circuits must have an ampere rating of 15 amperes »*Table 210.21(B)(3)*«.

Ⓑ A 20-ampere duplex receptacle shall not be installed on a 15-ampere circuit.

Ⓒ Receptacles installed on 20-ampere circuits can have an ampere rating of either 15 or 20 amperes »*Table 210.21(B)(3)*«.


15-Ampere Receptacles
A
15-Ampere Breaker
20-Ampere Receptacles
B
Violation
15-Ampere Breaker
15-Ampere Receptacles
C
20-Ampere Breaker
20-Ampere Receptacles
20-Ampere Breaker

Note

Branch circuits for receptacles shall not be smaller than 14 AWG »*210.19(D)*«. Generally, 15-ampere circuits require 14 AWG and 20-ampere circuits require 12 AWG copper conductors. Larger conductors may be needed to compensate for voltage drop or ambient temperature, or where more than three current-carrying conductors exist in a raceway or cable.

A Single Receptacle on an Individual Branch Circuit

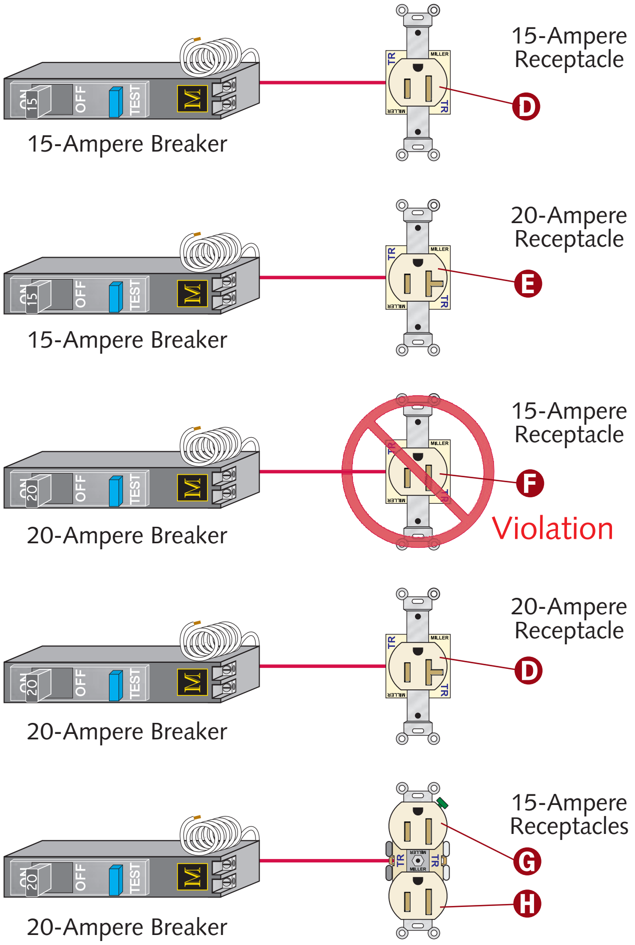
Ⓓ A single receptacle installed on a branch circuit with no other device or outlet shall have an ampere rating not less than the rating of that circuit »*210.21(B)(1)*«.

Ⓔ Installing two or more 20-ampere receptacles or outlets on a 15-ampere circuit is not permitted, but this requirement does not apply to a single receptacle [See 210.21(B)(1)]. Note, while there is no provision that prohibits installing a 20-ampere single receptacle on a 15-ampere circuit, there is a provision that does prohibit the load from exceeding the branch-circuit ampere rating. [See 210.22]

Ⓕ A 15-ampere single receptacle shall not be installed on a 20-ampere individual branch circuit.

Ⓖ A duplex receptacle is not a single receptacle. As defined in Article 100, a single receptacle is a single contact device with no other contact device on the same yoke or strap.

Ⓗ Receptacles on 20-ampere circuits can have a rating of either 15 or 20 amperes »*Table 210.21(B)(3)*«.


15-Ampere Receptacle
D
15-Ampere Breaker
20-Ampere Receptacle
E
15-Ampere Breaker
15-Ampere Receptacle
F
Violation
20-Ampere Breaker
20-Ampere Receptacle
D
20-Ampere Breaker
15-Ampere Receptacles
G
H
20-Ampere Breaker

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Dormitory Units, Guest Rooms, Guest Suites, and Similar Occupancies

A number of branch circuit and receptacle requirements that pertain to dwelling units also pertain to dormitory units, guest rooms, guest suites, and similar occupancies.

Guest room is an accommodation combining living, sleeping, sanitary, and storage facilities within a compartment »*Article 100 (Guest Room)*«.

Guest suite is an accommodation with two or more contiguous rooms comprising a compartment, with or without doors between such rooms, that provides living, sleeping, sanitary, and storage facilities »*Article 100 (Guest Suite)*«.

All 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets or devices installed in guest rooms and guest suites of hotels and motels and patient sleeping rooms in nursing homes and limited-care facilities shall be protected by any of the means described in 210.12(A)(1) through (6) »*210.12(D)*«. Section 210.12 pertains to arc-fault circuit-interrupter protection.

All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles in the areas specified in 406.12(1) through (10) shall be listed tamper-resistant receptacles. Some of the areas in 406.12(1) through (10) include: guest rooms and guest suites of hotels and motels; child care facilities; preschools and education facilities; assisted living facilities; and dormitory units.

Ⓐ Dormitory unit is a building or a space in a building in which group sleeping accommodations are provided for more than 16 persons who are not members of the same family in one room, or a series of closely associated rooms, under joint occupancy and single management, with or without meals, but without individual cooking facilities »*Article 100 (Dormitory Unit)*«.

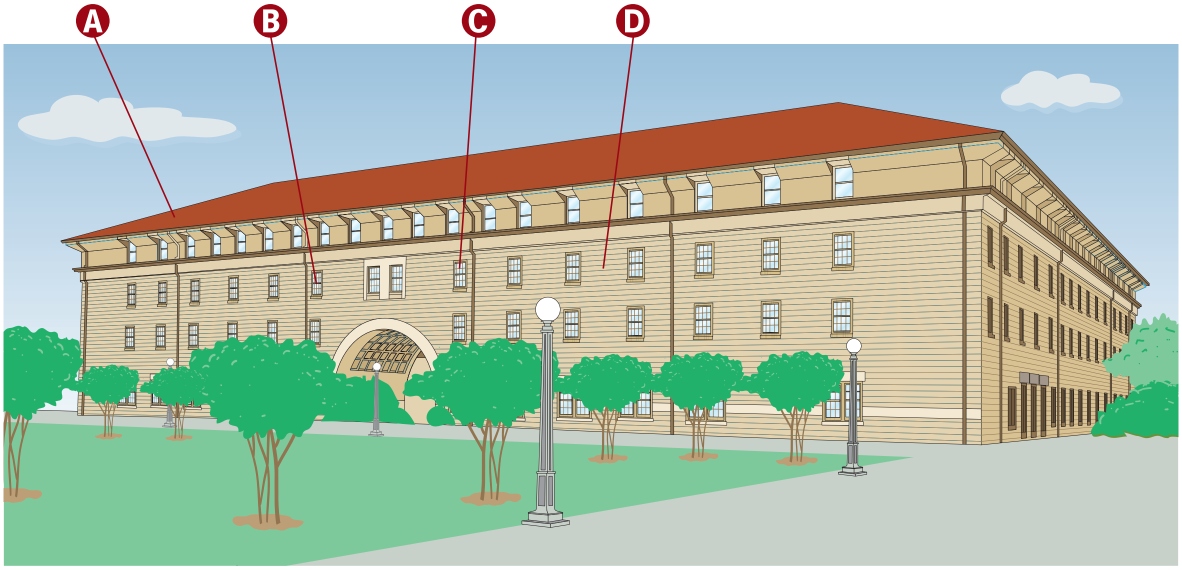
Ⓑ All 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets and devices installed in dormitory unit bedrooms, living rooms, hallways, closets, bathrooms, and similar rooms shall be protected by any of the means described in 210.12(A)(1) through (6) »*210.12(C)*«. Section 210.12 pertains to AFCI protection.

Ⓒ Guest rooms or guest suites in hotels, motels, sleeping rooms in dormitory units, and similar occupancies shall have receptacle outlets installed in accordance with 210.52(A) and (D). Guest rooms or guest suites provided with permanent provisions for cooking shall have receptacle outlets installed in accordance with all of the applicable rules in 210.52 »*210.60(A)*«. The total number of receptacle outlets shall not be less than required in 210.52(A). These receptacle outlets shall be permitted to be located conveniently for permanent furniture layout. At least two receptacle outlets shall be readily accessible. Where receptacles are installed behind the bed, the receptacle shall be located to prevent the bed from contacting any attachment plug that may be installed or the receptacle shall be provided with a suitable guard »*210.60(B)*«.

Ⓓ In dwelling units, dormitory units, and guest rooms or guest suites, overcurrent protective devices, other than supplementary overcurrent protection, shall not be located in bathrooms »*240.24(E)*«.

Note

AFCI protection is also required for all 120-volt, 10-, 15-, and 20-ampere branch circuits supplying outlets or devices installed in areas designed for use exclusively as sleeping quarters in fire stations, police stations, ambulance stations, rescue stations, ranger stations, and similar locations »***210.12(D)(3)***«.



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Receptacles

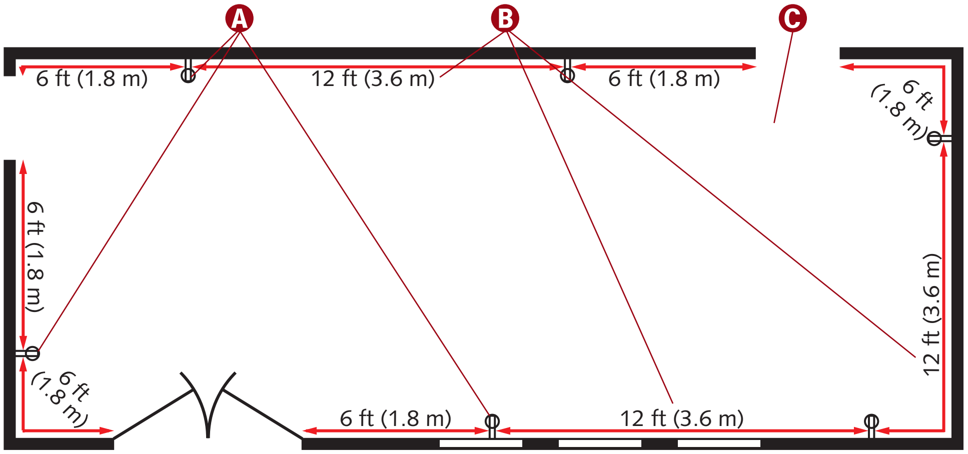
General Receptacle Placement

Wall space determines the minimum number of receptacles in a given dwelling. Receptacle outlets shall be installed in kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, sunrooms, bedrooms, recreation rooms, or similar rooms or areas in accordance with the provisions specified in 210.52(A).

A Receptacles shall be installed so that no point measured horizontally along the floor line of any wall space is more than 6 ft (1.8 m) from a receptacle outlet »*210.52(A)(1)*«.

B The maximum distance between receptacles is 12 ft (3.6 m).

C General receptacle placement requirements for 125-volt, 15- and 20-ampere receptacle outlets are in 210.52.



Caution

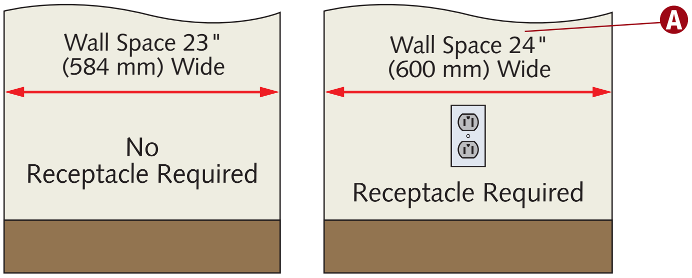
The receptacles required by 210.52(A) through (I) shall be in addition to any receptacle that is (1) part of a luminaire or appliance; (2) controlled by a listed wall-mounted control device in accordance with 210.70(A)(1) Exception No. 1; (3) located within cabinets or cupboards; or (4) located more than 5½ ft (1.7 m) above the floor »*210.52*«.

Note

Dwelling unit receptacle outlet general provisions specified in 210.52 apply to any part of a basement containing habitable rooms, such as a den, recreational room, etc.

Wall Spaces 2 ft (600 mm) in Width

A A receptacle is required for any wall space 2 ft (600 mm) or more in width (including space measured around corners), unbroken along the floor line by doorways and similar openings, fireplaces, stationary appliances, and fixed cabinets that do not have countertops or similar work surfaces »*210.52(A)(2)(1)*«.



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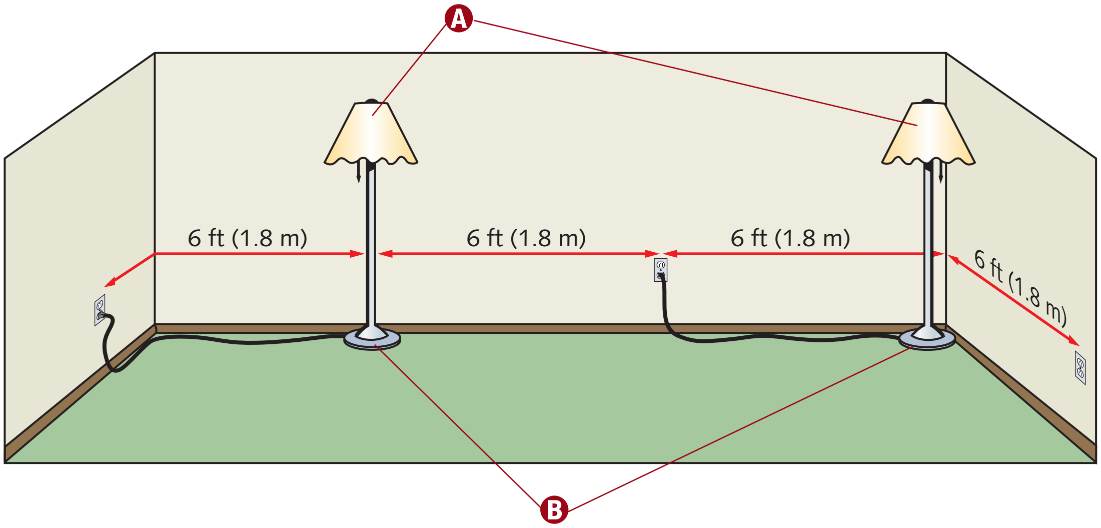
Maximum Distance to a Receptacle

A An easy way to understand the placement of dwelling receptacles is to imagine having a floor lamp with a 6-ft (1.8-m) cord. Anywhere this lamp is placed around the wall, there should be a receptacle within reach, without using an extension cord. Even when placed beside a door opening, an outlet should be within reach. If the lamp is placed next to a wall that is at least 24 in. (600 mm) wide, an outlet should be available within that wall space.

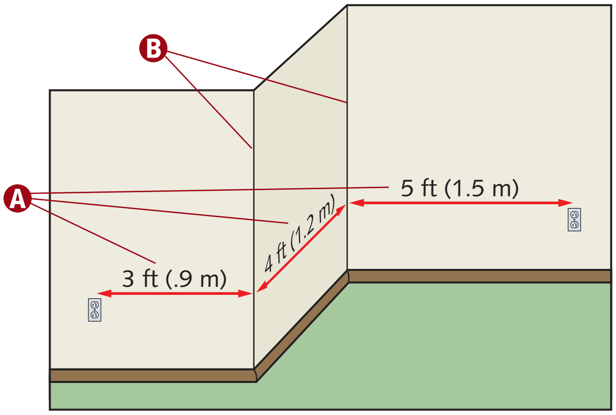
B The maximum distance to any receptacle, along the floor line of any wall space, measured horizontally, shall be 6 ft (1.8 m) »*210.52(A)(1)*«.



Space Measured around Corners

A The maximum distance **between receptacles** along the floor line of any wall space measured horizontally shall be 12 ft (3.6 m) »*210.52(A)(1)*«.

B Wall space includes space measured around corners »*210.52(A)(2)(1)*«.

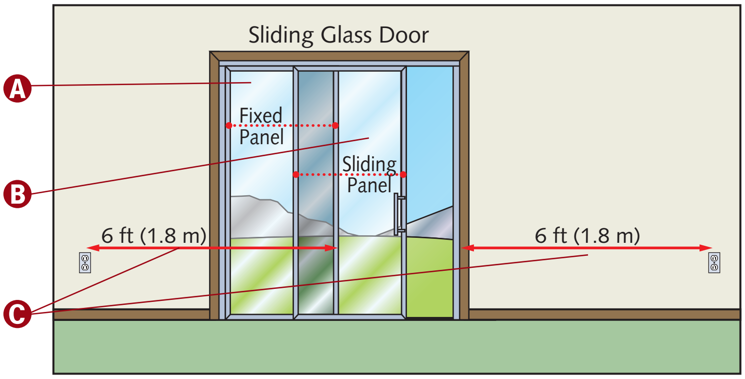


Fixed Panels

A Glass door fixed panels in exterior walls are counted as wall space »*210.52(A)(2)(2)*«.

B Sliding panels in exterior walls are not counted as wall space »*210.52(A)(2)(2)*«.

C The maximum distance to any receptacle along the floor line measured horizontally shall be 6 ft (1.8 m) »*210.52(A)(1)*«.



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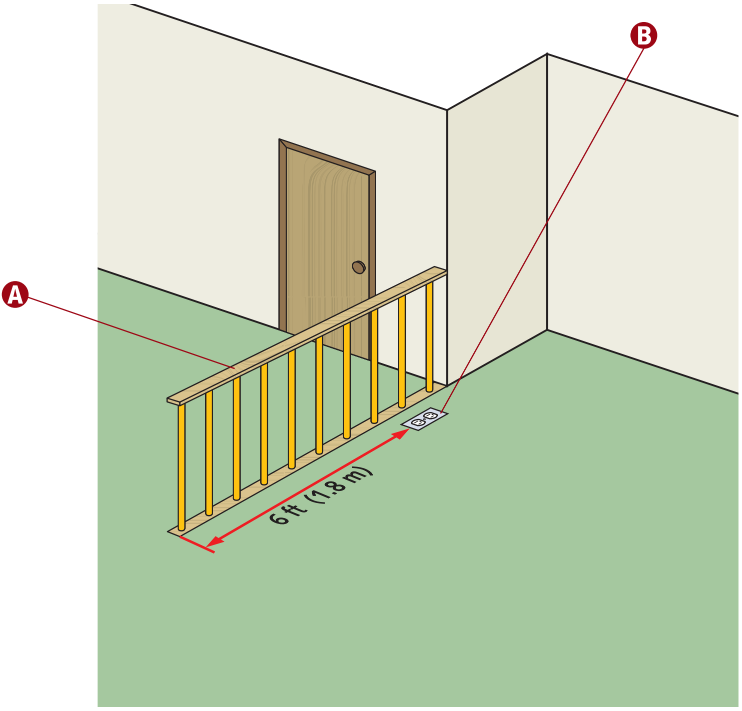
Fixed Room Dividers

A The space afforded by fixed room dividers, such as railings or freestanding bar-type counters, shall be counted as wall space »*210.52(A)(2)(3)*«.

B Receptacle outlets in or on floors are permitted. Receptacles located more than 18 in. (450 mm) from the wall (or room divider) may not be counted as required receptacles »*210.52(A)(3)*«.



Note

Not all types of receptacle boxes are suitable for floor installation. Different types of boxes may be required for different types of floor construction, that is, wood or concrete. Receptacle floor boxes must be listed specifically for the type of floor in which they are installed ***»314.27(B)«***.

Miscellaneous Receptacle Requirements

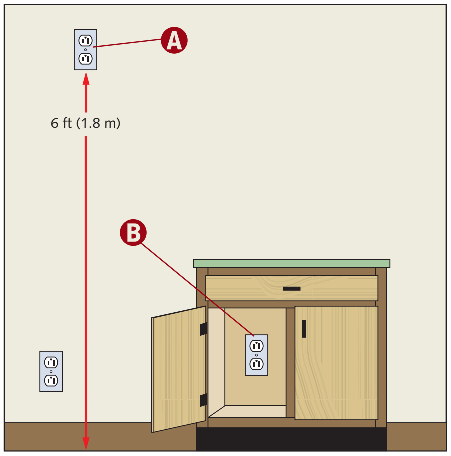
Luminaires or appliance(s) with built-in receptacle(s) are permitted, but these receptacles do not count as required receptacles »*210.52*«.

A Although receptacles located more than 5½ ft (1.7 m) above the floor are permitted, they are not counted as required receptacles »*210.52*«.

B Although receptacle outlets within cabinets or cupboards are permitted, they are not counted as required receptacles »*210.52*«.

Note

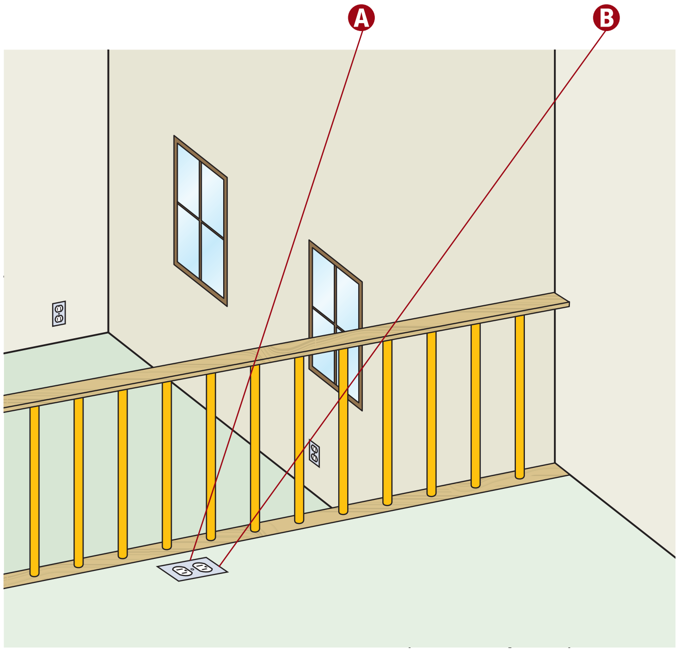
Height requirements for wall receptacles are not defined.



Balcony Handrail

A A receptacle floor box must be listed specifically for the type of floor in which it is installed »*314.27(B)*«.

B A floor receptacle may be required if a balcony handrail is longer than 6 ft (1.8 m) and the area is one listed in 210.52(A).



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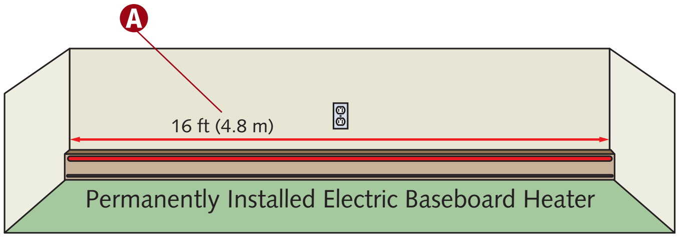
Electric Baseboard Heaters

Ⓐ A baseboard heater more than 12 ft (3.6 m) in length does not eliminate the requirements of 210.52(A)(1). A receptacle is still required for a wall space containing a baseboard heater.


Ⓐ
16 ft (4.8 m)
Permanently Installed Electric Baseboard Heater

Note

Listed or labeled equipment must be installed (and used) per any instructions included in the listing or labeling ***»110.3(B)«***.

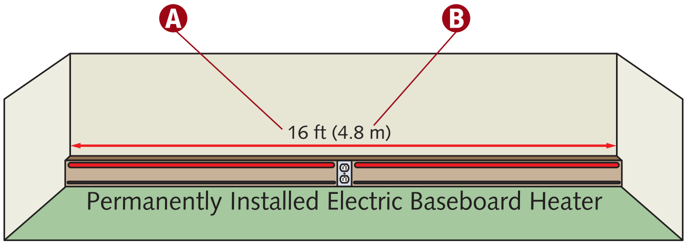
Caution

Listed baseboard heaters include instructions that may not permit their installation below receptacle outlets »*210.52 Informational Note* and *424.10 Informational Note*«.

Receptacles Mounted in Baseboard Heaters

Ⓐ Permanently installed electric baseboard heaters equipped with factory-installed outlets or outlets provided as a separate listed assembly by the manufacturer shall be permitted as the required outlet(s) for the wall space utilized by such permanently installed heaters »*210.52* and *424.10*«.

Ⓑ The receptacle outlet(s) shall not be connected to the heater circuit »*210.52* and *424.10*«.


Ⓐ
Ⓑ
16 ft (4.8 m)
Permanently Installed Electric Baseboard Heater

Receptacle Boxes

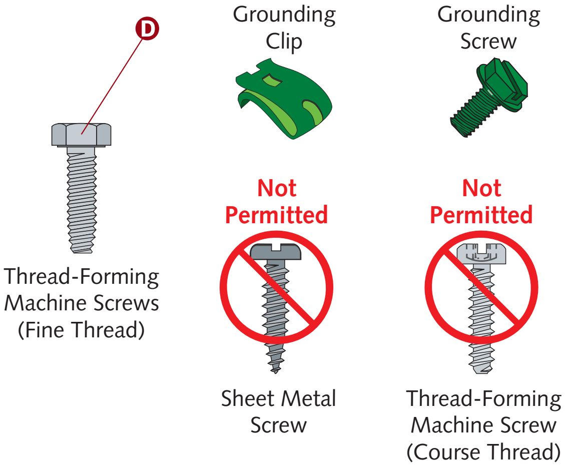
Receptacle boxes shall comply with Article 314. An expanded description of boxes, including box fill calculations, can be found in Unit 3 of this guidebook.

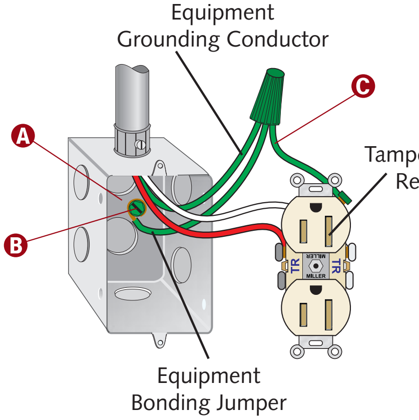
Ⓐ Metal raceways, cable trays, cable armor, cable sheath, enclosures, frames, fittings, and other metal non-current-carrying parts that serve as equipment grounding conductors (with or without the use of wire-type supplementary equipment grounding conductors) shall be bonded if necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed on them »*250.96(A)*«.

Ⓑ A connection shall be made between the equipment grounding conductor(s) and a metal box by means of a grounding screw used for no other purpose. Other grounding devices or equipment listed for grounding are allowed »*250.148(C)*«.

Ⓒ The arrangement of grounding connections shall be such that the disconnection or removal of a receptacle, luminaire, or other device fed from the box will not interfere with (or interrupt) the grounding continuity »*250.148(B)*«.

Ⓓ This thread-forming machine screw is permitted if at least two threads of the screw are engaged in the enclosure.


Ⓓ
Thread-Forming Machine Screws (Fine Thread)
Grounding Clip
Not Permitted
Sheet Metal Screw
Grounding Screw
Not Permitted
Thread-Forming Machine Screw (Course Thread)


Equipment Grounding Conductor
Ⓐ
Ⓑ
Ⓒ
Tamper-Resistant Receptacle
TR
TR
Equipment Bonding Jumper

Caution

Thread-forming machine screws that do not engage at least two threads in the enclosure shall not be used as grounding screws »*250.8*«.

Note

Self-tapping screws and self-drilling screws are not permitted because they are not the same as thread-forming machine screws.

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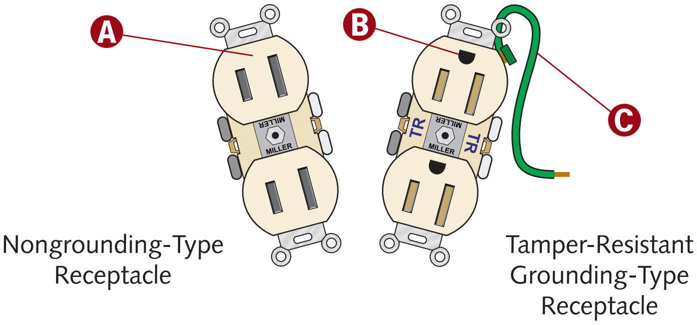
Grounding-Type Receptacles

Whereas 14 AWG copper conductors are required for 15-ampere circuits, 20-ampere circuits require 12 AWG »*240.4(D)*«.

Ⓐ Nongrounding-type receptacles may only be used to replace existing nongrounding receptacles (see "Receptacle Replacements" later in this unit).

Ⓑ Grounding-type receptacles shall be used on 15- and 20-ampere branch circuits except as provided in 406.4(D) »*406.4(A)*«.

Ⓒ For 15-, 20-, and 30-ampere circuits, the equipment grounding conductor shall be the same size as the current-carrying conductors »*Table 250.122*«. The grounding conductor size for a 15-ampere circuit is 14 AWG copper; for a 20-ampere circuit is 12 AWG; and for a 30-ampere circuit is 10 AWG.


A
B
C
MILLER
TR
Nongrounding-Type Receptacle
Tamper-Resistant Grounding-Type Receptacle

Note

Where receptacles have equipment grounding conductor contacts, those contacts shall be grounded by connection to the equipment grounding conductor of the circuit that supplies the receptacle »***406.4(B)* and *(C)***«.

Split-Wire Receptacles

Ⓐ A switch has been installed to control one of the ungrounded conductors in a multiwire branch circuit.

Ⓑ Each multiwire branch circuit must be provided with a means that simultaneously disconnects all ungrounded (hot) conductors at the point where the branch circuit originates »*210.4(B)*«. This is accomplished through the use of either one double-pole breaker or two single-pole breakers with identified handle ties.

Ⓒ A split-wire receptacle receiving power from a single source (one breaker or one fuse) is not a multiwire branch circuit.

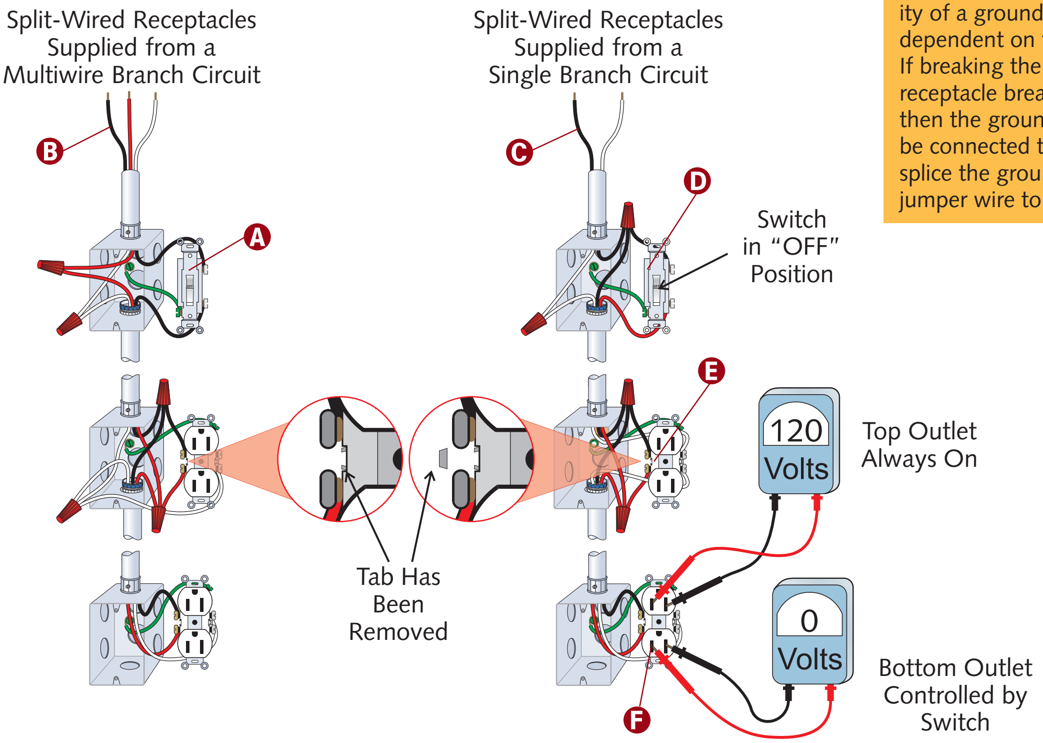
Ⓓ Switch-controlled, split-wire duplex receptacle(s) are sometimes installed in lieu of a lighting outlet »*210.70(A)(1) Exception No. 1*«.

Ⓔ The tab has been removed so one receptacle can be controlled from the switch and the other receptacle can remain live whether the switch is on or off.

Ⓕ One-half of the duplex receptacle is controlled by a wall switch, while the other half is a typical receptacle.

Warning

In multiwire branch circuits, the continuity of a grounded conductor shall not be dependent on the device »*300.13(B)*«. If breaking the grounded conductor at the receptacle breaks the circuit down the line, then the grounded conductors must not be connected to the receptacle. Simply splice the grounded conductors and install a jumper wire to the receptacle.


Split-Wired Receptacles Supplied from a Multiwire Branch Circuit
Split-Wired Receptacles Supplied from a Single Branch Circuit
A
B
C
D
E
F
Switch in "OFF" Position
Tab Has Been Removed
120 Volts
Top Outlet Always On
0 Volts
Bottom Outlet Controlled by Switch

Note

For additional information concerning multiwire branch circuits, see the definition located in Unit 2.

Note

Installing a grounded circuit conductor at the switch location is not required where the switch controls a receptacle load »***404.2(C)(4)***«.

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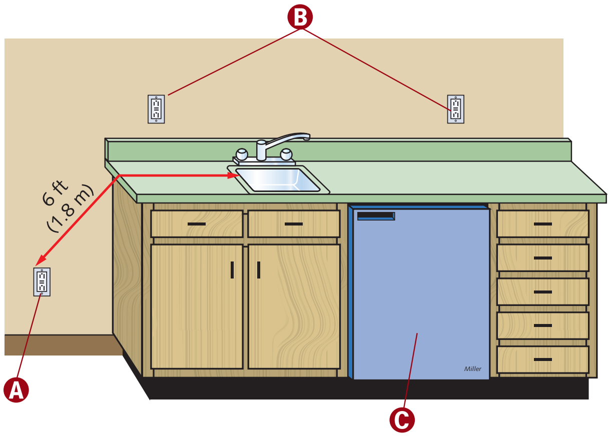
Wet Bar Receptacles

If located outside the kitchen, pantry, breakfast room, dining room, or similar area, wet bar countertop receptacle placement is not specified »*210.52(C)*«.

A Regardless of whether the receptacle serves countertop space or not, ground-fault circuit-interrupter (GFCI) protection is required if the receptacle is within 6 ft (1.8 m) from the top inside edge of the bowl of the sink »*210.8(A)(8)*«.

B GFCI protection is required where receptacles are installed in areas with sinks and permanent provisions for food preparation, beverage preparation, or cooking »*210.8(A)(7)*«.

C For cord-and-plug- (or attachment fitting-) connected appliances, an accessible separable connector or an accessible plug (or attachment fitting) and receptacle combination shall be permitted to serve as the disconnecting means. The attachment fitting shall be a factory-installed part of the appliance and suitable for disconnection of the appliance. Where the separable connector or plug (or attachment fitting) and receptacle combination are not accessible, cord-and-plug-connected or attachment fitting-and-plug-connected appliances shall be provided with disconnecting means in accordance with 422.31 »*422.33(A)*«.



Room Air Conditioner Receptacle

A If supplied by an individual 15- or 20-ampere branch circuit, the rating of a cord- and attachment plug-connected room air conditioner can be no more than 80% of the circuit's ampere rating »*210.23(B)(1)* and *440.62(B)*«.

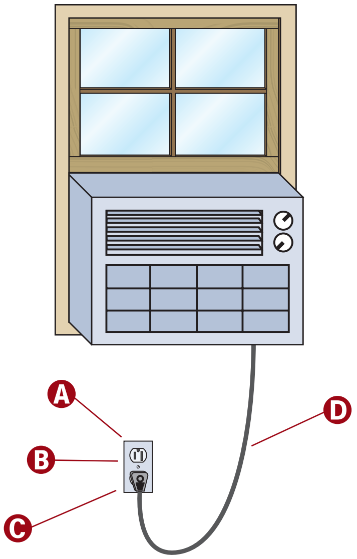
B Where other receptacles, lighting units, or appliances are also supplied, the rating of a cord- and attachment plug-connected room air conditioner shall not exceed 50% of the branch-circuit ampere rating for 15- and 20-ampere branch circuits »*210.23(B)(2)* and *440.62(C)*«.

C The attachment plug can serve as the disconnecting means »*440.13*«.

D The length of the supply cord shall not exceed 10 ft (3.0 m) for a 120-volt or 6 ft (1.8 m) for a 208- or 240-volt room air conditioner »*440.64*«.

Note

For additional provisions pertaining to room air conditioners, see Part VII of Article 440.



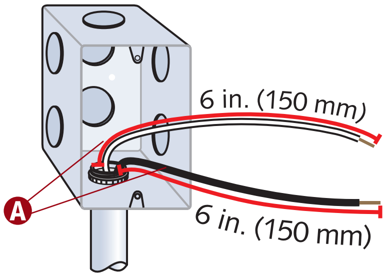
Length of Free Conductor

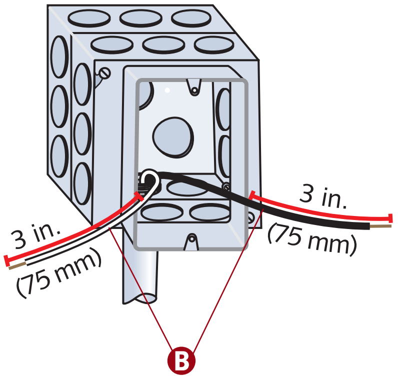
A At least 6 in. (150 mm) of free conductor, measured from the point in the box where it emerges from its raceway or cable sheath, shall be left at each outlet, junction, and switch point »*300.14*«.

B Conductors must extend a minimum of 3 in. (75 mm) outside of the box opening where the opening to the box is less than 8 in. (200 mm) in any dimension »*300.14*«.

Note

No minimum length is specified for conductors that are not spliced or terminated at the outlet, junction, or switch point »***300.14 Exception***«.





Note

The 6 in. (150 mm) of free conductor shall be permitted to be spliced or unspliced »***300.14***«.

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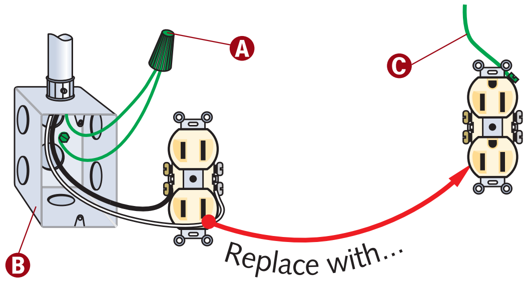
Receptacle Replacements

Grounding Means Present or Installed in the Enclosure

Ⓐ A grounding-type receptacle shall be installed in any receptacle enclosure having a grounding means *»406.4(D)(1)«*.

Ⓑ If an equipment grounding conductor is installed and connected to the grounding electrode system in accordance with 250.130(C), a grounding-type receptacle shall be installed *»406.4(D)(1)«*.

Ⓒ A grounding-type receptacle shall be connected to the equipment grounding conductor in accordance with 406.4(C) or 250.130(C).



Caution

Unless meeting the exception in this section, GFCI protected receptacles shall be provided where replacements are made at receptacle outlets that are required to be so protected elsewhere in the *NEC* *»406.4(D)(3)«*.
Where a receptacle outlet is located in any areas specified in 210.12(B), (C), or (D), a replacement receptacle at this outlet shall be one of the receptacles specified in 406.4(D)(4)(1), (2) or (3) unless meeting an exception *»406.4(D)(4)«*.
Listed tamper-resistant receptacles shall be provided where replacements are made at receptacle outlets that are required to be tamper-resistant elsewhere in the *NEC*, except where a non-grounding receptacle is replaced with another non-grounding receptacle or where aluminum branch-circuit conductors are directly terminated on a CO/ALR receptacle, installed as replacement *»406.4(D)(5)«*.

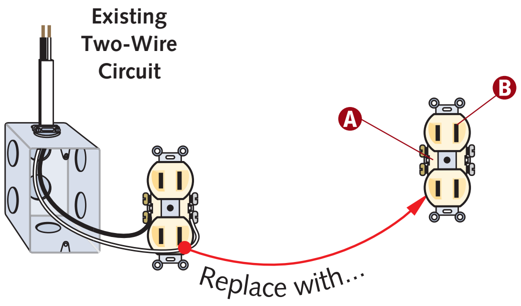
Note

An existing two-wire receptacle may be attached to a metal receptacle enclosure. Just because the box is metal does not guarantee that it is grounded to the grounding electrode system.

No Grounding Means Present . . . Nongrounding-Type Replaces Nongrounding-Type

Ⓐ Where attachment to an equipment grounding conductor does not exist in the receptacle enclosure, a nongrounding-type receptacle can replace an existing nongrounding-type receptacle *»406.4(D)(2)(a)«*.

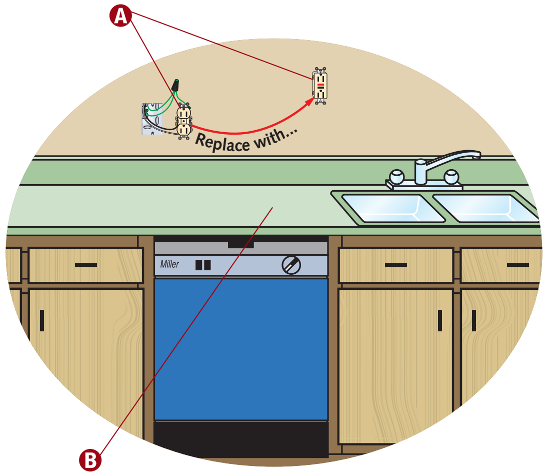
Ⓑ A non-grounding receptacle replacement is not required to be a tamper-resistant receptacle *»406.4(D)(5)«*.



Receptacles Requiring GFCI Protection

Ⓐ Because of changes in GFCI-protection requirements, some old receptacles must now be replaced with GFCI-protected receptacles *»406.4(D)(3)«*. Arc-fault circuit-interrupter type and ground-fault circuit-interrupter type receptacles shall be installed in a readily accessible location *»406.4(D)«*.

Ⓑ All receptacles installed in kitchens shall have GFCI protection *»210.8(A)(6)«*.



Note

Where replacement of the receptacle type is impracticable, such as where the outlet box size will not permit the installation of the GFCI receptacle, the receptacle shall be permitted to be replaced with a new receptacle of the existing type, where GFCI protection is provided and the receptacle is marked "GFCI Protected" and "No Equipment Ground," in accordance with 406.4(D)(2)(a), (b), or (c), as applicable ***»406.4(D)(3) Exception«***.

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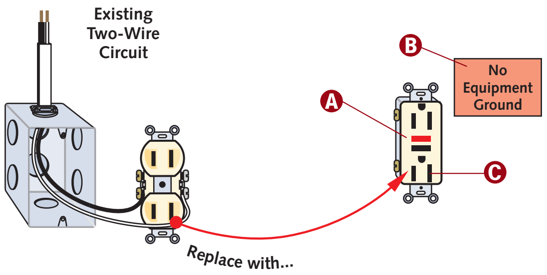
No Grounding Means Present . . . GFCI Replaces Nongrounding-Type

A Where attachment to an equipment grounding conductor does not exist in the receptacle enclosure, a GFCI receptacle can replace the old receptacle »*406.4(D)(2)(b)*«.

B This GFCI receptacle or its cover plate must be labeled **"No Equipment Ground"** »*406.4(D)(2)(b)*«.

C This GFCI replacement receptacle must be a listed tamper-resistant receptacle and may need to be AFCI protected »*406.4(D)(4)* and *406.4(D)(5)*«. Tamper-resistant receptacles may or may not be required when replacing receptacles in occupancies other than dwelling units. See 406.12 for other occupancies and areas where tamper-resistant receptacles are required.


Existing Two-Wire Circuit
B
No Equipment Ground
A
C
Replace with...

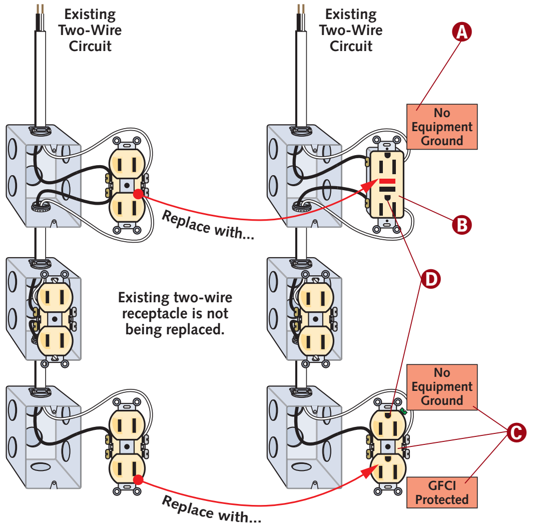
No Grounding Means Present . . . GFCI and Grounding-Type Replaces Nongrounding-Type

A This GFCI receptacle or its cover plate must be labeled **"No Equipment Ground"** »*406.4(D)(2)(b)*«.

B Where attachment to an equipment grounding conductor does not exist in the receptacle enclosure, a GFCI receptacle can replace an existing nongrounding-type receptacle »*406.4(D)(2)(b)*«.

C A grounding-type receptacle may replace a nongrounding-type receptacle where the circuit is ground-fault protected. These receptacles or their cover plates shall be labeled **"GFCI Protected"** and **"No Equipment Ground"**. These labels must be visible after installation »*406.4(D)(2)(c)*«.

D Do not connect an equipment grounding conductor between the grounding-type receptacles when multiple grounding-type receptacles are installed on an ungrounded circuit »*406.4(D)(2)(c)*«.


Existing Two-Wire Circuit
Existing Two-Wire Circuit
A
No Equipment Ground
Replace with...
B
D
Existing two-wire receptacle is not being replaced.
No Equipment Ground
C
GFCI Protected
Replace with...

Caution

An equipment grounding conductor shall not be connected from the GFCI-type receptacle to any outlet supplied from the GFCI receptacle »*406.4(D)(2)(b)*«.

Note

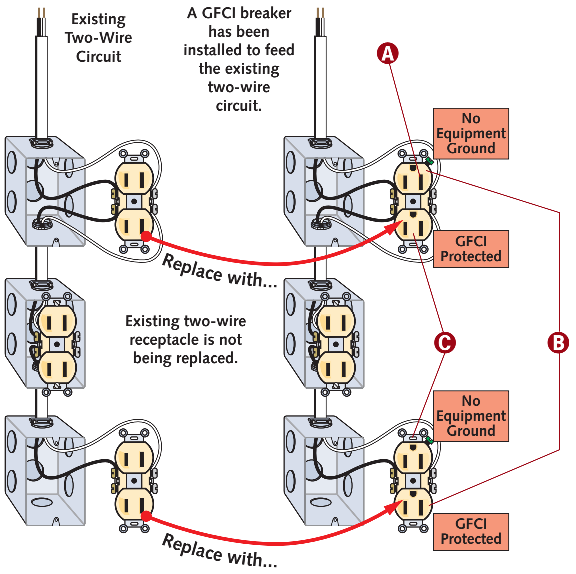
Arc-fault circuit-interrupter type and ground-fault circuit-interrupter type receptacles shall be installed in a readily accessible location »***406.4(D)***«.

No Grounding Means Present . . . Grounding-Type Replaces Nongrounding-Type

A A grounding-type receptacle may replace a nongrounding-type receptacle where the circuit is ground-fault protected.

B These receptacles or their cover plates shall be labeled **"GFCI Protected"** and **"No Equipment Ground"**. These labels must be visible after installation »*406.4(D)(2)(c)*«.

C Do not connect an equipment grounding conductor between the grounding-type receptacles when multiple grounding-type receptacles are installed on an ungrounded circuit »*406.4(D)(2)(c)*«.


Existing Two-Wire Circuit
A GFCI breaker has been installed to feed the existing two-wire circuit.
A
No Equipment Ground
GFCI Protected
Replace with...
Existing two-wire receptacle is not being replaced.
C
B
No Equipment Ground
GFCI Protected
Replace with...

Note

Consumers should be alerted to the fact that a receptacle is not grounded. This is especially important as more electronic equipment requires grounded receptacles.

Note

Some equipment or appliance manufacturers require that the branch circuit to the equipment or appliance includes an equipment grounding conductor »***406.4(D)(2) Informational Note No. 1***«.

See 250.114 for a list of a cord-and-plug-connected equipment or appliances that require an equipment grounding conductor »***406.4(D)(2) Informational Note No. 2***«.

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Receptacles Requiring AFCI Protection

A Where a receptacle outlet is located in any areas specified in 210.12(B), (C), or (D) a replacement receptacle at this outlet shall be one of the following:

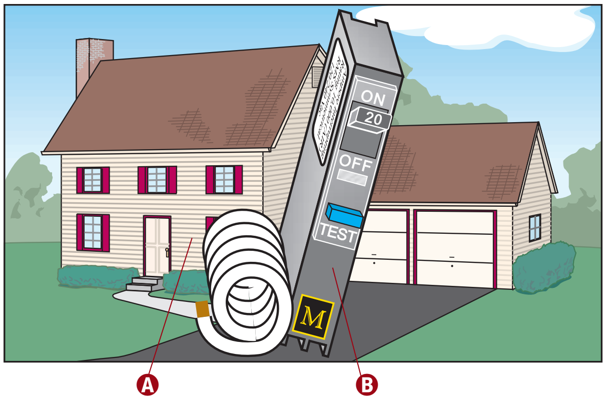
(1) A listed outlet branch-circuit type AFCI receptacle

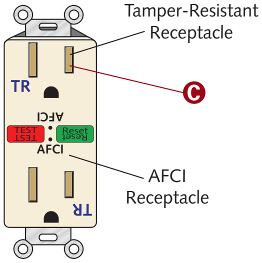
(2) A receptacle protected by a listed outlet branch-circuit type AFCI receptacle

(3) A receptacle protected by a listed combination-type AFCI circuit breaker »*406.4(D)(4)*«.

B Requirements for arc-fault circuit-interrupter protection are in 210.12.

C Listed tamper-resistant receptacles shall be provided where replacements are made at receptacle outlets that are required to be tamper-resistant elsewhere in the *NEC*, except where a non-grounding receptacle is replaced with another non-grounding receptacle or where aluminum branch-circuit conductors are directly terminated on a CO/ALR receptacle installed as replacement »*406.4(D)(5)*«.





Note

There is an exception in 210.12(D) that states AFCI protection shall not be required where the extension of the existing branch circuit conductors is not more than 6 ft (1.8 m) and does not include any additional outlets or devices, other than splicing devices. In accordance with the exception to 406.4(D), it is not permissible to use the exception in 210.12(E) when replacing receptacles.

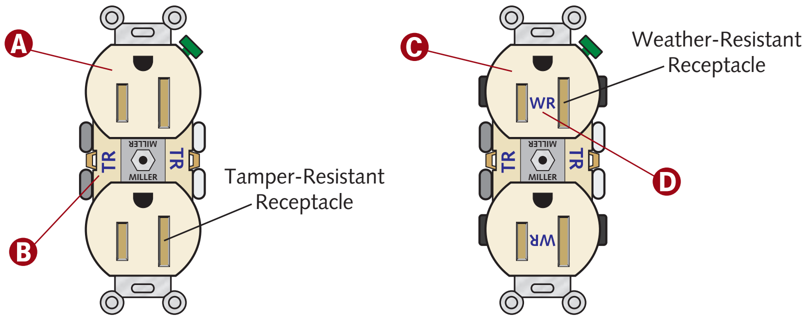
Other Considerations when Replacing Receptacles

A Listed tamper-resistant receptacles shall be provided where replacements are made at receptacle outlets that are required to be tamper-resistant elsewhere in the *NEC*, except where a non-grounding receptacle is replaced with another non-grounding receptacle or where aluminum branch-circuit conductors are directly terminated on a CO/ALR receptacle installed as replacement »*406.4(D)(5)*«. In dwelling units, all 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles shall be listed tamper-resistant receptacles. There is an exception for certain receptacles »*406.12*«.

B Tamper-resistant receptacles are identified by the letters "TR" or the words "Tamper Resistant." After the receptacle has been installed, the identification is only required to be visible with the cover-plate removed. See UL (Underwriter Laboratories) White Book, category: Receptacles for Plugs and Attachment Plugs (RTRT).

C Weather-resistant receptacles shall be provided where replacements are made at receptacle outlets that are required to be so protected elsewhere in the *NEC* »*406.4(D)(6)*«. All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles installed in damp and wet locations shall be listed weather-resistant type »*406.9(A)* and *406.9(B)(1)*«.

D Weather-resistant receptacles are identified by the letters "WR" or the words "Weather Resistant." After the receptacle has been installed, the identification must be visible with the cover plate secured in place. See UL (Underwriter Laboratories) White Book, category: Receptacles for Plugs and Attachment Plugs (RTRT).



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Lighting and Switching

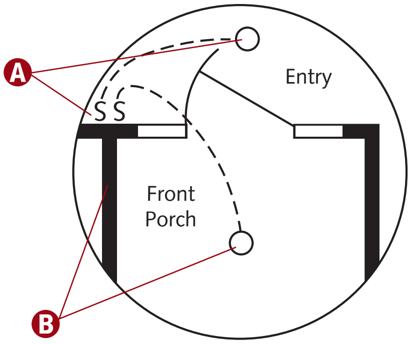
Outdoor Entrances and Exits

A At least one wall switch-controlled lighting outlet shall be installed in every habitable room of a dwelling »*210.70(A)(1)*«.

B At least one wall switch-controlled lighting outlet is required to provide exterior side illumination of outdoor entrances or exits having grade-level access »*210.70(A)(2)(2)*«.

Note

Remote, central, or automatic lighting control is permitted for outdoor entrances »***210.70(A)(2) Exception***«.



General Lighting

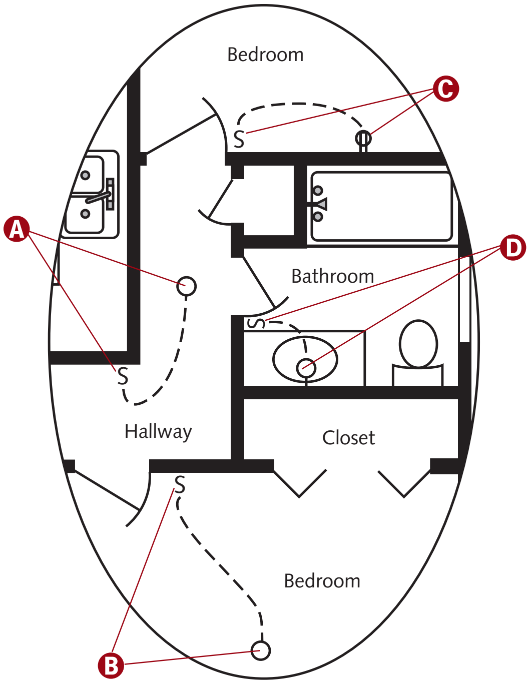
All switches shall be located so that they may be operated from a readily accessible place, not more than 6 ft, 7 in. (2.0 m), from the floor to the center of the switch operating handle »*404.8(A)*«. No other height requirements are stipulated for wall switches.

A Dwelling hallways require a minimum of one wall switch-controlled lighting outlet »*210.70(A)(2)(1)*«.

B At least one wall switch-controlled lighting outlet shall be installed in every habitable room, kitchen, laundry area, and bathroom of a dwelling »*210.70(A)(1)*«.

C Except for kitchens, laundry areas, and bathrooms, every habitable room is permitted one or more wall switch-controlled receptacle(s) in lieu of a lighting outlet »*210.70(A)(1) Exception No. 1*«. Switch-controlled receptacles allow for cord-connected lighting.

D At least one wall switch-controlled lighting outlet shall be installed in every bathroom of a dwelling »*210.70(A)(1)*«.



Note

Occupancy sensors are permitted to control lighting outlets in lieu of wall switches. One of two requirements must be met in order to use occupancy sensors: either a regular wall switch must be present in addition to the sensor, or the sensor must be equipped with a manual override that allows the sensor to function as a switch. Either type of wall switch shall be located at a customary location »***210.70(A)(1) Exception No. 2***«.

Switches Controlling Lighting Loads

A Where switches control lighting loads supplied by a grounded general-purpose branch circuit, the grounded circuit conductor for the controlled lighting circuit shall be installed at the switch location »*404.2(C)*«.

B The provision for a (future) grounded conductor is to complete a circuit path for electronic lighting control devices »*404.2(C) Informational Note*«.

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Note

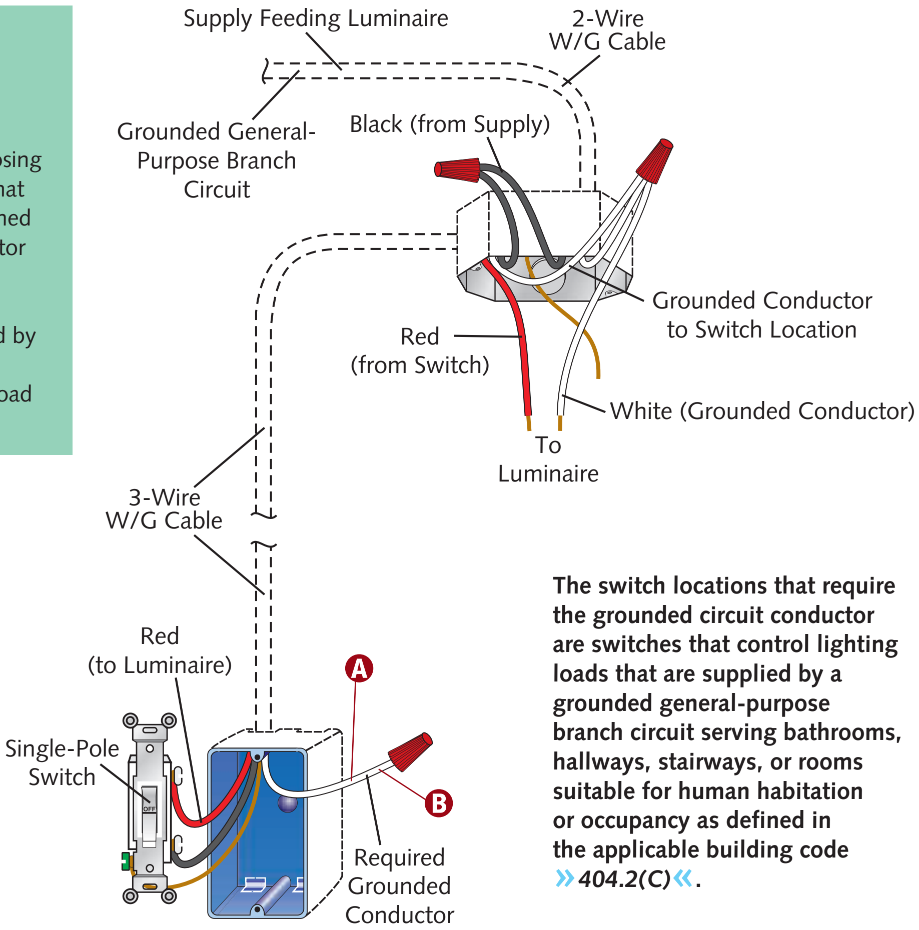
The grounded circuit conductor shall be permitted to be omitted from the switch enclosure for the following

(1) Where conductors enter the box enclosing the switch through a raceway, provided that the raceway is large enough for all contained conductors, including a grounded conductor

(2) Where snap switches with integral enclosures comply with 300.15(E)

(3) Where lighting in the area is controlled by automatic means

(4) Where a switch controls a receptacle load ***»404.2(C)«***.



The switch locations that require the grounded circuit conductor are switches that control lighting loads that are supplied by a grounded general-purpose branch circuit serving bathrooms, hallways, stairways, or rooms suitable for human habitation or occupancy as defined in the applicable building code *»404.2(C)«*.

Note

The grounded conductor shall be extended to any switch location as necessary and shall be connected to switching devices that require line-to-neutral voltage to operate the electronics of the switch in the standby mode and shall meet the requirements of 404.22 ***»404.2(C)«***. The connection requirement shall not apply to replacement or retrofit switches installed in locations prior to local adoption of 404.2(C) and where the grounded conductor cannot be extended without removing finish materials. The number of electronic lighting control switches on a branch circuit shall not exceed five, and the number connected to any feeder on the load side of a system or main bonding jumper shall not exceed 25. For the purpose of this exception, a neutral busbar, in compliance with 200.2(B) and to which a main or system bonding jumper is connected shall not be limited as to the number of electronic lighting control switches connected ***»404.2(C) Exception«***.

Multiple Switches Controlling the Same Lighting Loads

Ⓐ Where multiple switch locations control the same lighting load such that the entire floor area of the room or space is visible from the single or combined switch locations, the grounded circuit conductor shall only be required at one location *»404.2(C)«*.

Ⓑ The reidentified white conductor in this box is carrying power to a 3-way switch. There is no grounded conductor in this box.

Ⓒ There is no grounded conductor in this box. The reidentified white conductor is used as a switch leg.

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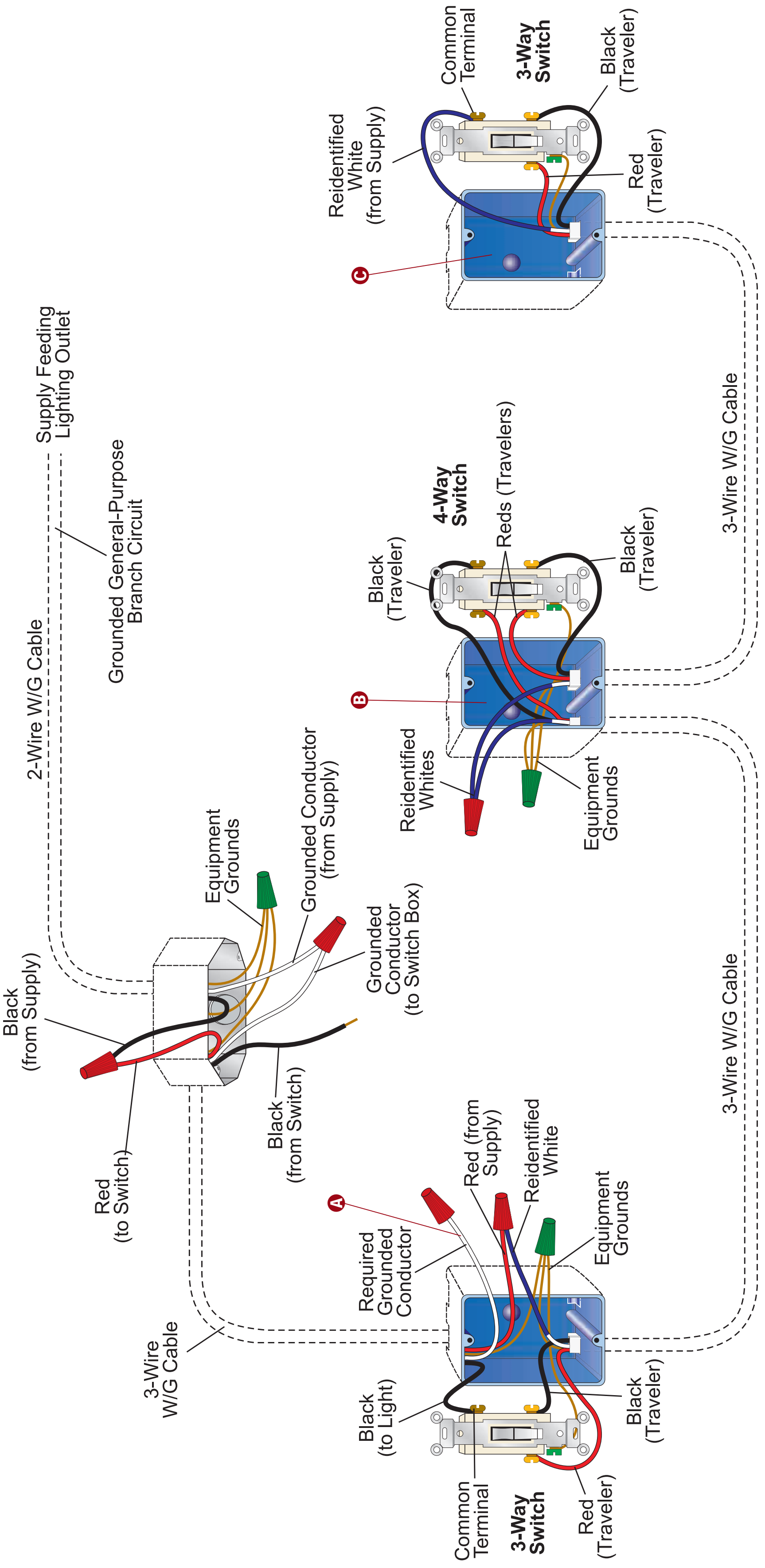
Supply Feeding Lighting Outlet
Grounded General-Purpose Branch Circuit
2-Wire W/G Cable
Black (from Supply)
Red (to Switch)
Black (from Switch)
Equipment Grounds
Grounded Conductor (from Supply)
Grounded Conductor (to Switch Box)
3-Wire W/G Cable
A
Required Grounded Conductor
Red (from Supply)
Reidentified White
Equipment Grounds
Black (to Light)
Common Terminal
3-Way Switch
Red (Traveler)
Black (Traveler)
3-Wire W/G Cable
B
Reidentified Whites
Equipment Grounds
Black (Traveler)
4-Way Switch
Reds (Travelers)
Black (Traveler)
3-Wire W/G Cable
C
Reidentified White (from Supply)
Common Terminal
3-Way Switch
Black (Traveler)
Red (Traveler)

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Ceiling-Suspended (Paddle) Fans

Include any light kit or accessory when determining the total weight of the fan.

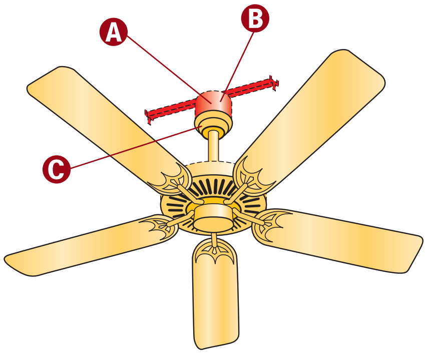
Ⓐ Outlet boxes or outlet box systems used as the sole support of a ceiling-suspended (paddle) fan shall be listed, shall be marked by their manufacturer as suitable for this purpose, and shall not support ceiling-suspended (paddle) fans that weigh more than 70 pounds (32 kg). For outlet boxes or outlet box systems designed to support ceiling-suspended (paddle) fans that weigh more than 35 pounds (16 kg), the required marking must include the maximum weight that can be supported »*314.27(C)*«.

Ⓑ In a completed installation, each outlet box shall be provided with a cover unless covered by means of a ceiling-suspended (paddle) fan canopy »*422.20*«. Any combustible ceiling finish that is exposed between the edge of a ceiling-suspended (paddle) fan canopy or pan and an outlet box and that has a surface area of 180 in.^{2} (1160 mm^2) or more shall be covered with noncombustible material »*422.21*«.

Ⓒ Canopies of ceiling-suspended (paddle) fans and outlet boxes taken together shall provide sufficient space so that conductors and their connecting devices are capable of being installed in accordance with 314.16 »*422.19*«.

Warning

Even if a ceiling-suspended (paddle) fan will not be installed initially, it may be necessary to install a box (ceiling fan box) that is listed to support a ceiling-suspended (paddle) fan. In accordance with 314.27(C), outlet boxes mounted in the ceilings of habitable rooms of dwelling occupancies in a location acceptable for the installation of a ceiling-suspended (paddle) fan shall be either
(1) listed for the sole support of ceiling-suspended (paddle) fans, or
(2) installed so as to allow direct access through the box to structural framing capable of supporting a ceiling-suspended (paddle) fan without removing the box.



Note

Ceiling-suspended (paddle) fans shall be supported independently of an outlet box or by one of the following:
(1) A listed outlet box or listed outlet box system identified for the use and installed in accordance with 314.27(C)
(2) A listed outlet box system, a listed weight-supporting ceiling receptacle, and a compatible factory installed weight-supporting attachment fitting that is installed in accordance with 314.27(E) »***422.18(A)***«.

Cables Installed to Feed Switches

No provision permits the installation of a smaller conductor as a switch loop. Switch loops (legs) that are part of a 20-ampere branch circuit cannot be smaller than 12 AWG copper conductors. Table 210.24 requires 12 AWG conductors throughout a 20-ampere branch circuit, except for taps. Taps and switch loops are not the same.

A white conductor in a cable can be used as an ungrounded conductor when supplying power to a switch, but not as a return conductor from the switch to the outlet.

The conductor shall be permanently reidentified to indicate its use by marking tape, painting, or other effective means at its terminations and at each location where the conductor is visible and accessible »*200.7(C)(1)*«. The reidentified conductor can be any color except white, gray, or green.

Ⓐ A connection used for no other purpose shall be made between the metal box and the equipment grounding conductor(s) in accordance with 250.8 »*250.148(C)*«.

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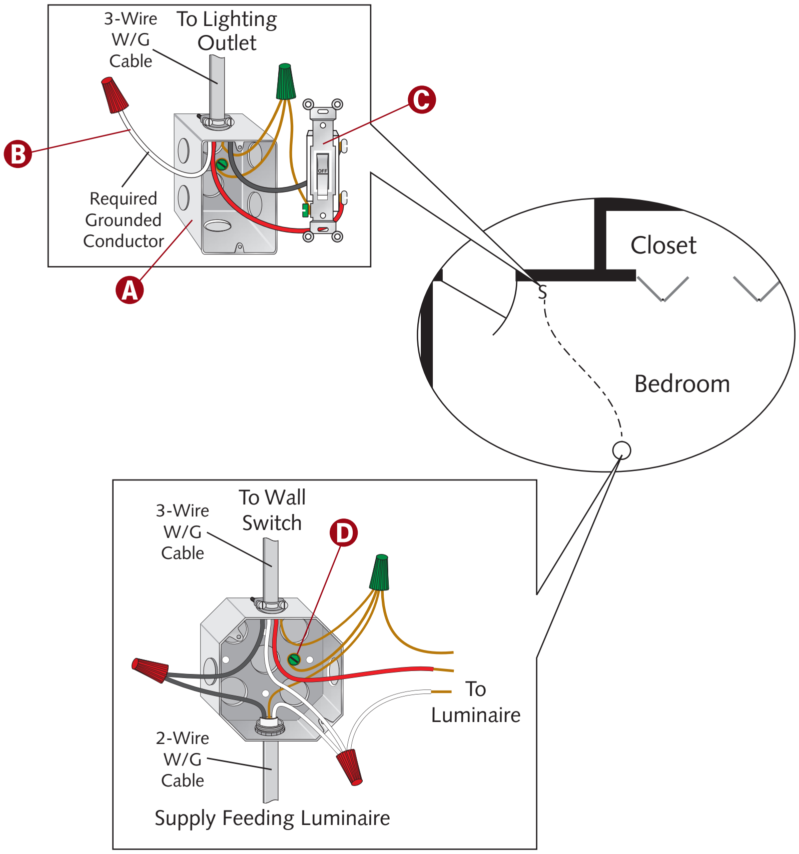
B The grounded circuit conductor for the controlled lighting circuit shall be installed at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit serving bathrooms, hallways, stairways, and habitable rooms or occupiable spaces as defined in the applicable building code »*404.2(C)*«.

C Snap switches, including dimmer and similar control switches, shall be connected to an equipment grounding conductor and shall provide a means to connect metal faceplates to the equipment grounding conductor, whether or not a metal faceplate is installed. Metal faceplates shall be bonded to the equipment grounding conductor. Snap switches, dimmers, control switches, and metal faceplates shall be connected to an equipment grounding conductor using either of the following methods: (1) the switch is mounted with metal screws to a metal box or metal cover that is connected to an equipment grounding conductor or to a nonmetallic box with integral means for connecting to an equipment grounding conductor; or (2) an equipment grounding conductor or equipment bonding jumper is connected to an equipment grounding termination of the snap switch »*404.9(B)*«.

D If circuit conductors are spliced within a box, or terminated on equipment within or supported by a box, all equipment grounding conductor(s) associated with any of those circuit conductors shall be connected within the box or to the box with devices suitable for the use in accordance with 250.8 and 250.148(A) through (D) »*250.148*«.

Note

An outlet box used exclusively for lighting can support a luminaire or lampholder weighing no more than 50 pounds (23 kg), unless the box is listed for not less than the weight to be supported and marked for the maximum weight the box shall be permitted to support. A separate means for supporting a luminaire (independent of the outlet box) is also permitted »***314.27(A)(2)***«.

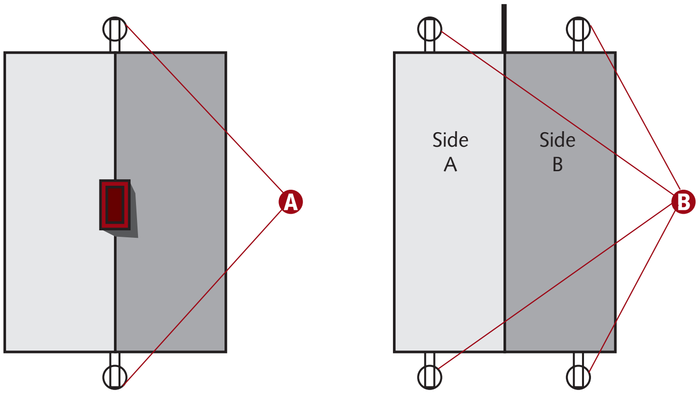


Outdoor Receptacles and Lighting

Required Outdoor Receptacles

A One-family dwellings require at least one receptacle outlet installed at the front and back of the dwelling. Each receptacle must be readily accessible from grade and located not more than 6 ft, 6 in. (2.0 m) above grade level »*210.52(E)(1)*«.

B *Each* grade level unit of a two-family dwelling requires at least one receptacle outlet installed at the front and back of the dwelling. Each receptacle must be readily accessible from grade and located not more than 6 ft, 6 in. (2.0 m) above grade level »*210.52(E)(1)*«.



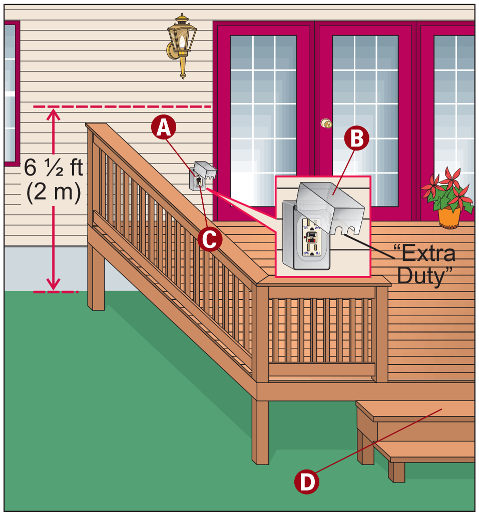
Balconies, Decks, and Porches

A Balconies, decks, and porches that are within 4 in. (102 mm) horizontally of the dwelling unit shall have at least one receptacle outlet accessible from the balcony, deck, or porch. The receptacle outlet shall not be located more than $6\frac{1}{2}$ ft (2.0 m) above the balcony, deck, or porch walking surface »*210.52(E)(3)*«.

B Receptacles of 15 and 20 amperes, 125 and 250 volts installed in wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed and shall be identified as "extra duty." Other listed products, enclosures, or assemblies providing weatherproof protection that do not utilize an outlet box hood need not be marked "extra duty". All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles shall be listed weather-resistant type »*406.9(B)(1)*«.

C Because this receptacle is readily accessible from grade and not more than $6\frac{1}{2}$ ft (2.0 m) above grade level, it can be counted as the required receptacle at the back of a dwelling »*210.52(E)(1)*«. It can also be counted as the required deck receptacle that is accessible from inside the dwelling.

D Although the receptacle on the deck is not within reach while standing at grade level, it is readily accessible from grade.



Note

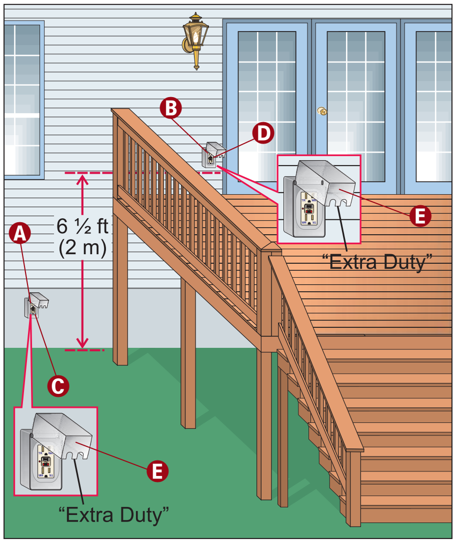
Hinged covers of outlet box hoods shall be able to open 90 degrees or fully open if the cover is not designed to open 90 degrees from the closed to open position after installation »***406.9(A)* and *406.9(B)(1)***«.

Receptacles More Than 6 ft 6 in. (2.0 m) above Grade

A For a one-family dwelling and each unit of a two-family dwelling that is at grade level, at least one receptacle outlet readily accessible from grade and not more than $6\frac{1}{2}$ ft (2.0 m) above grade level shall be installed at the front and back of the dwelling »*210.52(E)(1)*«.

B Balconies, decks, and porches that are within 4 in. (102 mm) horizontally of the dwelling unit shall have at least one receptacle outlet accessible from the balcony, deck, or porch. The receptacle outlet shall not be located more than $6\frac{1}{2}$ ft (2.0 m) above the balcony, deck, or porch walking surface »*210.52(E)(3)*«.

C Because this receptacle is readily accessible from grade and not more than $6\frac{1}{2}$ ft (2.0 m) above grade level, it can be counted as the required receptacle at the back of a dwelling »*210.52(E)(1)*«.



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D This receptacle is more than 6½ ft above grade level and therefore, cannot be counted as the required receptacle at the back of a dwelling.

E Receptacles of 15 and 20 amperes, 125 and 250 volts installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed and shall be identified as "extra duty". Other listed products, enclosures, or assemblies providing weatherproof protection that do not utilize an outlet box hood need not be marked "extra duty" »*406.9(B)(1)*«.

Caution

Outdoor receptacles require GFCI protection »*210.8(A)(3)*«.

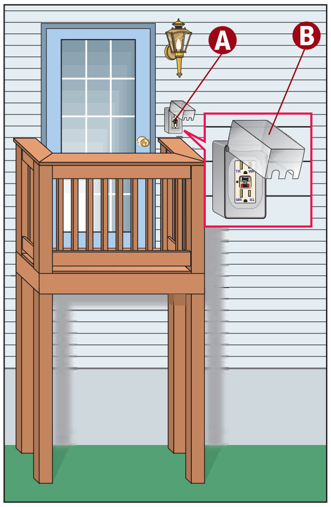
Note

GFCI protection is not required for receptacles that are not readily accessible and are supplied by a branch circuit dedicated to electric snow melting-, deicing-, or pipeline- and vessel-heating equipment. The installation must comply with 426.28 or 427.22, as applicable »***210.8(A) Exception No. 1***«. (See 426.28 and 427.22 for ground-fault protection of equipment.) Outdoor receptacles that are not readily accessible (such as under an eave) require GFCI protection.

Small Balconies, Decks, and Porches

A All balconies, decks, and porches that are within 4 in. (102 mm) horizontally of the dwelling unit shall have the required receptacle outlet regardless of size. There is no exception for small balconies, decks, or porches. For example, this balcony has an area that is less than 10 ft^2. Because this balcony is within 4 in. (102 mm) horizontally of the dwelling, there shall be at least one receptacle outlet accessible from the balcony, deck, or porch. The receptacle outlet shall not be located more than 6½ ft (2.0 m) above the balcony, deck, or porch walking surface »*210.52(E)(3)*«.

B This weatherproof receptacle cover is listed and is identified as "extra duty."



Receptacles in Damp and Wet Locations

A An outdoor receptacle, in a location protected from the weather or in other damp locations, requires an enclosure for the receptacle that is weatherproof when the receptacle is covered (attachment plug cap not inserted and receptacle covers closed). Receptacle locations protected from the weather include areas such as under roofed open porches, canopies, marquees, etc., that are not subjected to a beating rain or water runoff »*406.9(A)*«.

B The enclosure for a receptacle installed in a flush-mounted outlet box in a finished surface requires the use of a weatherproof faceplate assembly that provides a watertight seal between the plate and the finished surface »*406.9(D)*«.

C An installation suitable for wet locations shall also be considered suitable for damp locations »*406.9(A)*«.

D Receptacles of 15 and 20 amperes installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed and shall be identified as "extra-duty." Other listed products, enclosures, or assemblies providing weatherproof protection that do not utilize an outlet box hood need not be marked "extra duty" »*406.9(B)(1)*«.

E All 15- and 20-ampere, 125- and 250-volt nonlocking receptacles installed in damp and wet locations shall be listed and so identified as the weather-resistant type »*406.9(A)* and *406.9(B)(1)*«.

F Unless meeting one of the exceptions in this section, all 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles in the areas specified in 406.12(1) through (10) shall be listed tamper-resistant receptacles. (1) All dwelling units, boathouses, mobile homes, and manufactured homes, including their attached and detached garages, accessory buildings, and common areas (2) Guest rooms and guest suites of hotels, motels, and their common areas (3) Childcare facilities (4) Preschools and education facilities (5) Business offices accessible to the general public, lobbies and waiting spaces, and spaces of nursing homes and limited care facilities covered in 517.10(B)(2) within clinics, medical and dental offices, and outpatient facilities (6) Places of awaiting transportation, gymnasiums, skating rinks, fitness centers, and auditoriums (7) Dormitory units (8) Residential care/assisted living facilities, social and substance abuse rehabilitation facilities, and group homes (9) Foster care facilities, nursing homes, and psychiatric hospitals (10) Areas of agricultural buildings accessible to the general public and common areas »*406.12*«.

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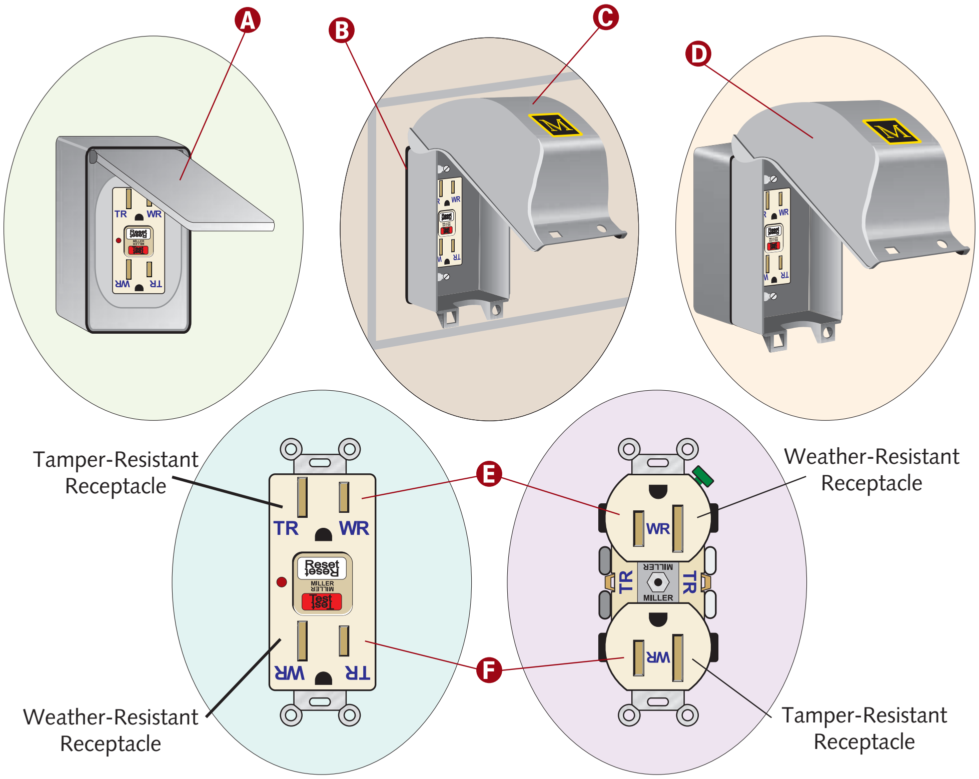

A
B
C
D
TR
WR
Reset
Test
M
Tamper-Resistant Receptacle
E
Weather-Resistant Receptacle
MILLER
F
Weather-Resistant Receptacle
Tamper-Resistant Receptacle

Note

Hinged covers of outlet box hoods shall be able to open 90 degrees or fully open if the cover is not designed to open 90 degrees from the closed to open position after installation »*406.9(A)* **and** *406.9(B)(1)*«.

Note

All 15- and 20-ampere, 125- through 250-volt receptacles installed in a wet location and subject to routine high-pressure spray washing shall be permitted to have an enclosure that is weatherproof when the attachment plug is removed »*406.9(B)(1) Exception*«.

Warning

When replacing receptacles, compliance with 406.4(D)(1) through (8) is required. In accordance with 406.12, tamper-resistant receptacles are required in dwelling units including garages (attached and detached) and accessory buildings. In accordance with 406.9(A) and (B)(1), listed weather-resistant type receptacles are required. In older dwellings, it may be necessary to provide GFCI and AFCI protection for replacement receptacles.

Equipment Outlet

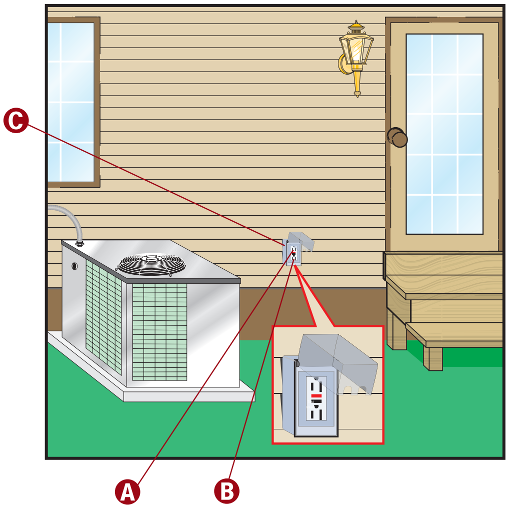
A A 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed at an accessible location for the servicing of heating, air-conditioning, and refrigeration equipment. The receptacle shall be located on the same level and within 25 ft (7.5 m) of the heating, air-conditioning, and refrigeration equipment »*210.63* and *210.63(A)*«.

B At least one receptacle outlet, readily accessible from grade and not more than 6½ ft (2.0 m) above grade level, shall be installed at the front and back of the dwelling »*210.52(E)(1)*«.

C If installed in accordance with both 210.52(E) and 210.63(A), only one receptacle outlet is required.

Note

A receptacle outlet shall not be required at one- and two-family dwellings for the service of evaporative coolers »*210.63(A) Exception*«.



Caution

The receptacle outlet shall not be connected to the load side of the equipment's branch-circuit disconnecting means »*210.63(A)*«.

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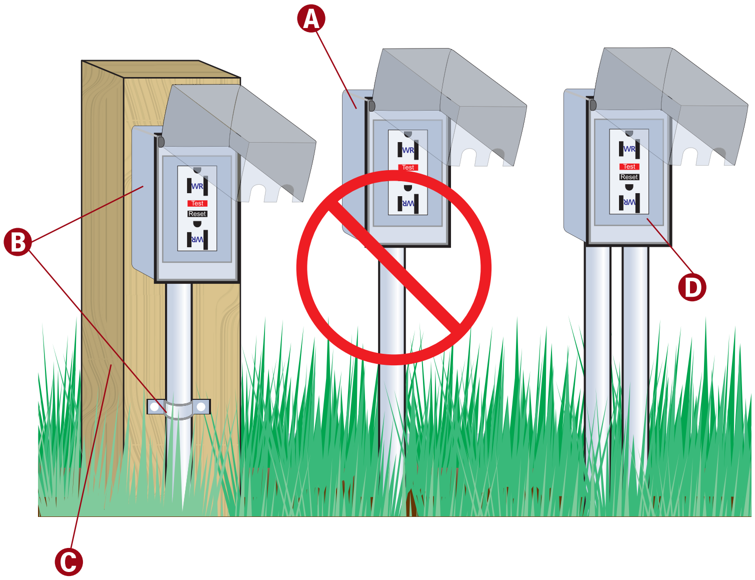
Support for Receptacle Enclosures

A As a general rule, a single conduit shall not support an enclosure that contains a device ››*314.23(F)*‹‹.

B Rigidly and securely fasten in place all boxes and raceways ››*300.11(A)* and *314.23(A)*‹‹.

C Supporting an enclosure from grade requires rigid support in the form of conduit or a brace (metal, polymeric, or wood) ››*314.23(B)*‹‹. Wood brace cross sections must be at least 1 in. × 2 in. (25 mm × 50 mm). Wood braces must be treated to withstand the conditions when used in wet locations ››*314.23(B)(2)*‹‹.

D An enclosure containing devices can be supported by two conduits under the conditions found in 314.23(F): (1) the box shall not exceed 100 in.^{3} (1650 cm^3); (2) the box has either threaded entries or identified hubs; (3) the box shall be supported by two or more conduits threaded wrenchtight into the enclosure or hubs; and (4) each conduit shall be secured within 18 in. (450 mm) of the enclosure.



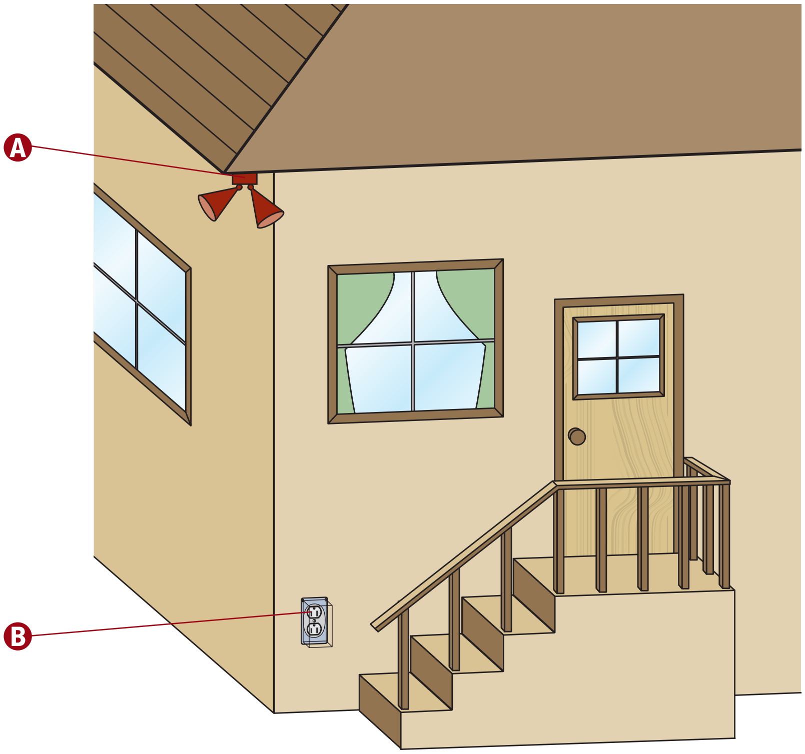
Note

Dwelling-unit outdoor receptacles require GFCI protection for personnel **››*210.8(A)(3)*‹‹**.

Illumination of Entrances and Exits

A Install at least one wall switch-controlled lighting outlet to provide illumination on the exterior side of outdoor entrances and exits (doorways) with grade-level access. This applies to all dwelling units, attached garages, and detached garages with electric power ››*210.70(A)(2)(2)*‹‹. It is not required that the luminaire be located adjacent to the doorway, as long as illumination around the doorway is provided.

B Install at least one receptacle outlet at the front and back of the dwelling ››*210.52(E)(1)*‹‹. Outdoor receptacles are required to be GFCI protected ››*210.8(A)(3)*‹‹.



Note

A vehicle door in a garage shall not be considered an outdoor entrance or exit **››*210.70(A)(2)(2)*‹‹**.

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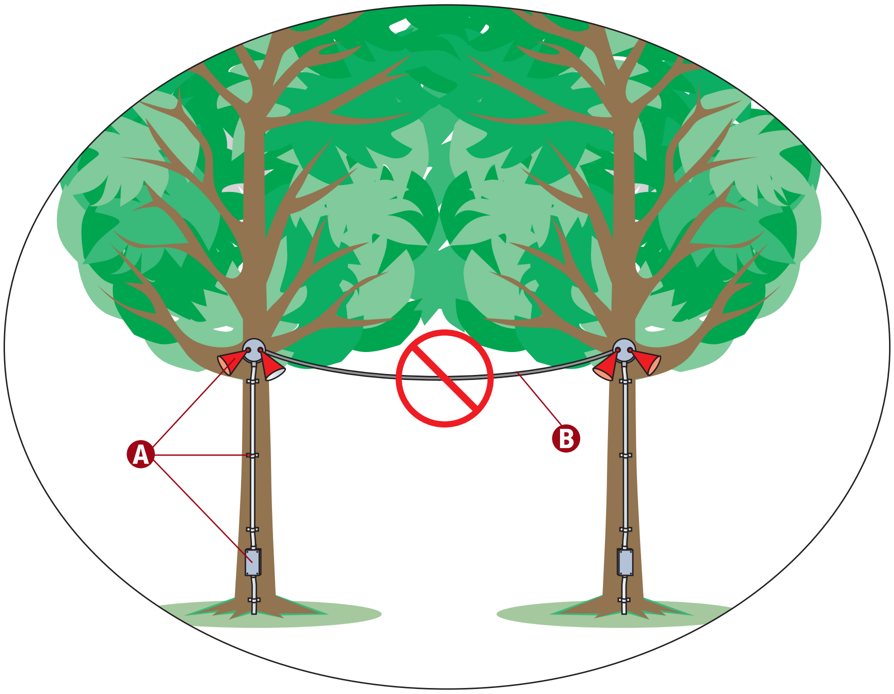
Wiring in Trees

A Outdoor luminaires and associated equipment can be supported by trees »410.36(G)«.

B Vegetation (such as trees) shall not be used to support overhead conductor spans »225.26«.

Note

Direct-buried conductors and cables emerging from grade and specified in columns 1 and 4 of Table 300.5(A) shall be protected by enclosures or raceways that extend from the minimum cover distance below grade required by 300.5(A) to a point 8 ft (2.5 m) or more above finished grade. In no case shall the protection be required to exceed 18 in. (450 mm) below finished grade »300.5(D)(1)«.



Summary

- All 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets or devices installed in dwelling-unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar rooms or areas shall be protected by any of the arc-fault circuit-interrupter types described in 210.12(A)(1) through (6).
- All nonlocking-type 125- and 250-volt, 15- and 20-ampere receptacles, in dwelling units, shall be listed tamper-resistant receptacles.
- Balconies, decks, and porches that are within 4 in. (102 mm) horizontally of the dwelling unit shall have at least one receptacle outlet accessible from the balcony, deck, or porch.
- General-purpose branch circuits may feed lights, receptacles, or any combination of those items.
- An individual branch circuit feeds only one piece of equipment.
- The maximum distance to any receptacle measured horizontally along the floor line is 6 ft (1.8 m).
- A receptacle is required for any wall space 2 ft (600 mm) or wider.
- Where connected to a branch circuit supplying two or more receptacles or outlets, receptacles rated 20 amperes are not permitted on a 15-ampere branch circuit.
- Both 15- and 20-ampere receptacles are permitted on 20-ampere branch circuits.
- GFCI-protected receptacles may replace nongrounding-type receptacles where the receptacle enclosure is without a grounding means.
- GFCI-protected receptacles on nongrounded systems must be marked in accordance with 406.4(D)(2) provisions.
- A means to simultaneously disconnect all ungrounded conductors must be provided on multiwire branch circuits.
- A switch-controlled lighting outlet shall be installed in every habitable room of a dwelling, including bathrooms, hallways, and stairways.
- Where switches control lighting loads supplied by a grounded general-purpose branch circuit for other than the items described in 404.2(C), the grounded circuit conductor for the controlled lighting circuit shall be provided at the switch location.
- Boxes are permitted to support luminaires weighing 50 pounds (23 kg) or less.
- Listed boxes are permitted to support ceiling fans weighing no more than 35 pounds (16 kg) unless marked with the maximum weight to be supported.
- One-family dwellings require at least one exterior GFCI-protected receptacle outlet at the front and back of the dwelling.
- Outdoor entrances and exits must have at least one wall switch-controlled lighting outlet.
- Although lighting and receptacles can be supported by trees, trees shall not support overhead conductor spans.

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Unit 6 Competency Test

***NEC*® Reference** **Answer**

____________ ____________ 1. A duplex receptacle rated 20 amperes can be installed on a ____________ branch circuit.

a) 15-ampere b) 20-ampere

c) 15- or 20-ampere d) 20- or 25-ampere

____________ ____________ 2. The continuity of a grounded conductor shall not be dependent on the device in ____________.

a) branch circuits not having a grounded conductor

b) multiwire branch circuits

c) individual branch circuits

d) branch circuits

____________ ____________ 3. In dwelling units, receptacle outlets located more than ____________ ft above the floor are not counted in the required number of receptacles along the wall.

____________ ____________ 4. At least ____________ in. of free conductor, measured from the point in the box where it emerges from its raceway or cable sheath, shall be left at each outlet, junction, and switch point for splices or the connection of luminaires or devices.

____________ ____________ 5. In nonmetallic-sheathed cable, the equipment grounding conductor for 15-, 20-, and 30-ampere branch circuits ____________.

a) is required only with aluminum or copper-clad aluminum cable

b) must be the same size as the insulated circuit conductors

c) may be one size smaller than the insulated circuit conductors

d) may be two sizes smaller than the insulated circuit conductors

____________ ____________ 6. A 20-ampere, 125-volt receptacle installed within ____________ ft from the top inside edge of the bowl of the sink shall have ground-fault circuit-interrupter protection for personnel.

____________ ____________ 7. What is the minimum number of 120-volt, 15-ampere branch circuits required for the lighting and general use receptacle outlets in a one-family dwelling with an area of 1800 ft^2?

____________ ____________ 8. Which of the following is not a standard classification for a branch circuit supplying several loads?

a) 20 amperes b) 25 amperes c) 30 amperes d) 50 amperes

____________ ____________ 9. For dwelling units, attached garages, and detached garages with electric power, at least one lighting outlet controlled by a ____________ shall be installed to provide illumination on the exterior side of outdoor entrances or exits with grade-level access.

____________ ____________ 10. Grounding-type receptacles shall be installed only on circuits of the ____________ for which they are rated, except as provided in Tables 210.21(B)(2) and (B)(3).

I. voltage class

II. wattage

III. current

a) I only b) I and III only c) I and II only d) I, II, and III

____________ ____________ 11. Outlet boxes or outlet box systems used as the sole support of a ceiling-suspended (paddle) fan shall be listed, shall be marked by their manufacturer as suitable for this purpose, and shall not support ceiling-suspended (paddle) fans that weigh more than ____________ pounds.

____________ ____________ 12. Receptacle outlets in or on floors shall not be counted as part of the required number of receptacle outlets in a dwelling unit unless they are located within ____________ in. of the wall.

***NEC*® Reference** **Answer**

___________ ___________ 13. For a one-family dwelling that is at grade level, at least one receptacle outlet readily accessible from grade and not more than ___________ ft above grade level shall be installed at the front and back of the dwelling.

___________ ___________ 14. A luminaire that weighs more than ___________ pounds shall be supported independently of the outlet box, unless the outlet box is listed and marked on the interior of the box to indicate the maximum weight the box shall be permitted to support.

___________ ___________ 15. A duplex receptacle rated 15 amperes can be installed on a ___________ ampere general-purpose branch circuit.

___________ ___________ 16. A branch circuit that supplies only one utilization equipment is known as a(n) ___________ branch circuit.

___________ ___________ 17. As a general rule, the maximum spacing between receptacle outlets in a dwelling unit is ___________ ft.

___________ ___________ 18. A nongrounding-type receptacle has been replaced with a new grounding-type duplex receptacle. The 15-ampere circuit breaker feeding the circuit has been replaced with a 15-ampere ground-fault circuit breaker. The new receptacle or its cover plate must be marked ___________ and be visible after installation.

I. "Two-Wire Circuit"

II. "No Equipment Ground"

III. "GFCI Protected"

a) III only b) I and III only c) II and III only d) I, II, and III

___________ ___________ 19. A branch circuit that supplies two or more receptacles or outlets for lighting and appliances is a(n) ___________ branch circuit.

___________ ___________ 20. All switches shall be installed such that the center of the grip of the operating handle of the switch, when in its highest position, is not more than ___________ above the floor or working platform.

___________ ___________ 21. Switch-controlled receptacles (in lieu of a lighting outlet) are permitted in all but which of the following?

a) Bedroom b) Living room c) Dining room d) Hallway

___________ ___________ 22. A single receptacle rated 50 amperes can be installed on a ___________-ampere individual branch circuit.

___________ ___________ 23. In dwelling units, arc-fault circuit-interrupter protection shall not be required for 120-volt, single-phase, 15- and 20-ampere branch circuits supplying outlets or devices installed in ___________.

a) kitchens b) bathrooms c) laundry areas d) closets

___________ ___________ 24. The definition of a branch circuit is ___________.

a) the circuit conductors between the service and the subpanel

b) the circuit conductors prior to the final overcurrent device protecting the circuit

c) the circuit conductors between the final overcurrent device protecting the circuit and the outlet(s)

d) the circuit conductors between the final overload device protecting the circuit and the outlet(s)

___________ ___________ 25. In dwelling units, a duplex receptacle fed from a multiwire branch circuit must have ___________ as a means of disconnect.

I. two single-pole circuit breakers without identified handle ties

II. one double-pole circuit breaker

III. two single-pole circuit breakers with identified handle ties

a) I only b) I or II only c) II only d) II or III only

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Unit 7

Section Two: One-Family Dwellings

Specific Provisions

Objectives

After studying this unit, the student should be able to:

- recall the required ampere rating for receptacles and branch circuits in general as well as specific locations throughout a dwelling unit.
- summarize the requirements for kitchen countertop receptacle placement, including island countertop spaces and peninsular countertop spaces.
- recall the minimum number of circuits required for kitchens, pantries, dining rooms, breakfast rooms, and similar areas.
- explain the requirements pertaining to permanently connected, as well as cord- and plug-connected, appliances.
- calculate loads for appliance branch circuits.
- clarify which locations are required to have GFCI-protected receptacles.
- recall the requirements for hallway and stairway receptacles and lighting.
- list which luminaires are, and which are not, permitted in closets, and the placement thereof.
- explain the definition of a bathroom and the requirements for receptacles, lighting, and fans located in bathrooms.
- summarize the requirements for receptacles and lighting in attached garages, detached garages, and basements.
- recall the requirements for laundry (including clothes dryers) receptacles and branch circuits.
- summarize the requirements for attic and crawl space lighting and receptacles.
- clarify lighting and receptacle requirements around HVAC equipment.

Introduction

Unit 6 contains provisions concerning general areas both inside and outside of one-family dwellings. The material in Unit 7 addresses more complex issues, requiring additional provisions for specific areas (such as kitchens, hallways, clothes closets, bathrooms, garages, basements, etc.). For instance, a kitchen may require the general provisions found in Unit 6, as well as specific provisions found in this unit. A dining room having no countertop surface requires receptacle placement by the general rule, but it must be fed from a 20-ampere branch circuit. Some areas require only one receptacle outlet, while bathroom receptacle requirements depend on the number and location of sinks. This unit also includes specific requirements for lighting outlets and switches. The pages that follow provide significant information on specific provisions for areas such as kitchens, dining rooms, breakfast rooms, hallways, stairways, clothes closets, bathrooms, attached as well as detached garages, basements, attics, and crawl spaces.

Kitchens, Dining Rooms, and Breakfast Rooms

Receptacle and Branch-Circuit Rating

Receptacle placement in a kitchen is determined by 210.52(A) and (C). All of the general receptacle placement provisions found in 210.52(A) apply, as well as additional requirements found in 210.52(C) for countertops.

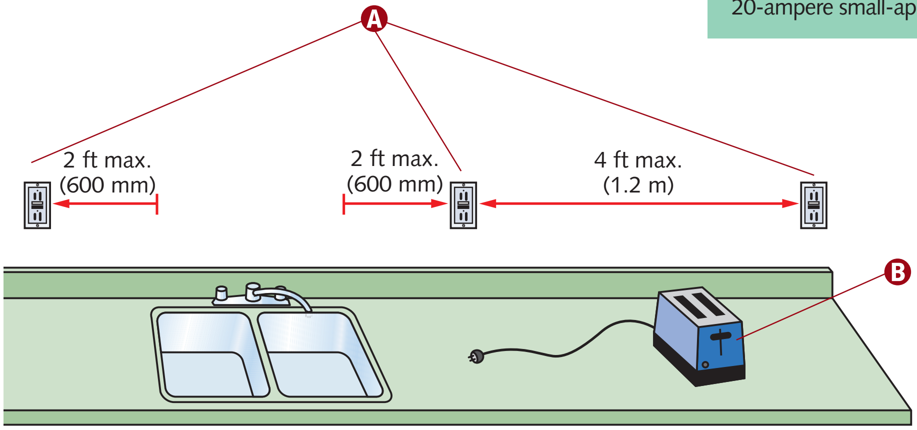
A Receptacles installed on the 20-ampere small-appliance circuits may be rated either 15 or 20 amperes »*Table 210.21(B)(3)*«.

All receptacles installed in kitchens shall have GFCI protection »*210.8(A)(6)*«.

B The maximum distance to any receptacle, measured horizontally along the wall line, is 24 in. (600 mm) »*210.52(C)(1)*«. An easy way to understand countertop receptacle placement is to imagine a toaster with a 24-in. (600-mm) cord. Anywhere this toaster is placed around the countertop wall, there should be a receptacle within reach.

Note

In kitchens, pantries, breakfast rooms, dining rooms, or similar areas of a dwelling unit, circuits that serve countertop surface receptacles and general-purpose receptacles shall be 20-ampere small-appliance branch circuits **»*210.52(B)(1)*«**.



Note

Receptacle outlets are only required to be installed behind a range, counter-mounted cooking unit, or sink if the area behind the range, counter-mounted cooking unit, or sink is 12 in. (300 mm) or greater when installed parallel to the adjoining wall or 18 in. (450 mm) or greater if installed in a corner **»*210.52(C)(1) Exception No. 1*«**.

Other Outlets Fed from Small-Appliance Branch Circuits

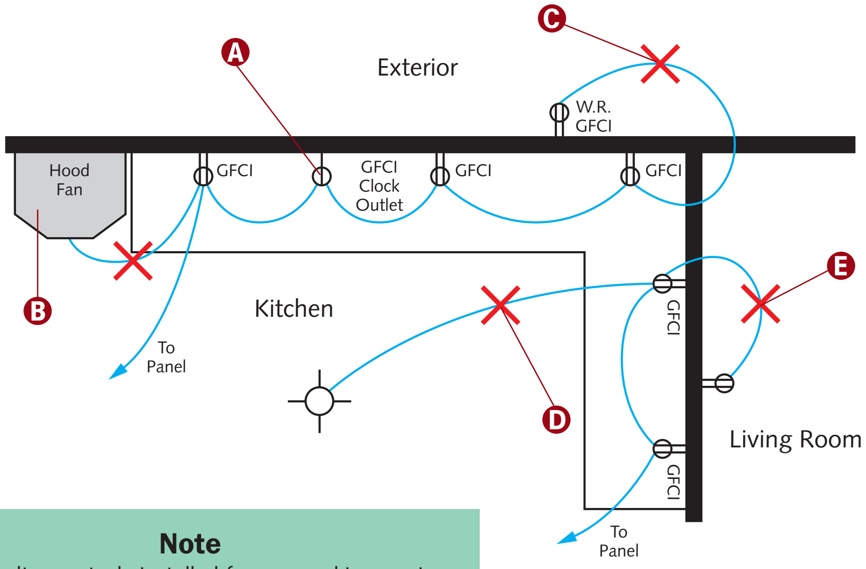
A A dedicated clock outlet, installed to provide power and support, is permitted on a small-appliance branch circuit »*210.52(B)(2) Exception No. 1*«.

B A hood fan is not permitted on a small-appliance branch circuit »*210.52(B)(2)*«.

C Outdoor receptacles are not permitted on small-appliance branch circuits »*210.52(B)(2)*«.

D A lighting outlet is not permitted on a small-appliance branch circuit »*210.52(B)(2)*«.

E Circuits feeding receptacles in kitchens, pantries, breakfast rooms, dining rooms, or similar areas shall not feed receptacles outside of these areas »*210.52(B)(2)*«.



Note

A 120-volt receptacle installed for gas cooking equipment can be fed from a small-appliance branch circuit **»*210.52(B)(2) Exception No. 2*«**.

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Kitchen Countertop Receptacle Placement

All **receptacles installed in kitchens shall have GFCI protection »*210.8(A)(6)*«.**

Branch circuits in kitchens shall be 20-ampere circuits »*210.11(C)(1)* and *210.52(B)(1)*«.

A minimum of two small-appliance branch circuits are required for receptacles serving kitchen countertops »*210.52(B)(3)*«. Either or both of these small-appliance branch circuits may feed other receptacles in the kitchen, pantry, breakfast room, or dining area.

Receptacles located more than 20 in. (500 mm) above countertops or work surfaces are allowed but do not count as required receptacles »*210.52(C)(3)(1)*«.

Receptacles inside appliance garages are permitted, but do not count as required countertop receptacles »*210.52(C)(3)*«.

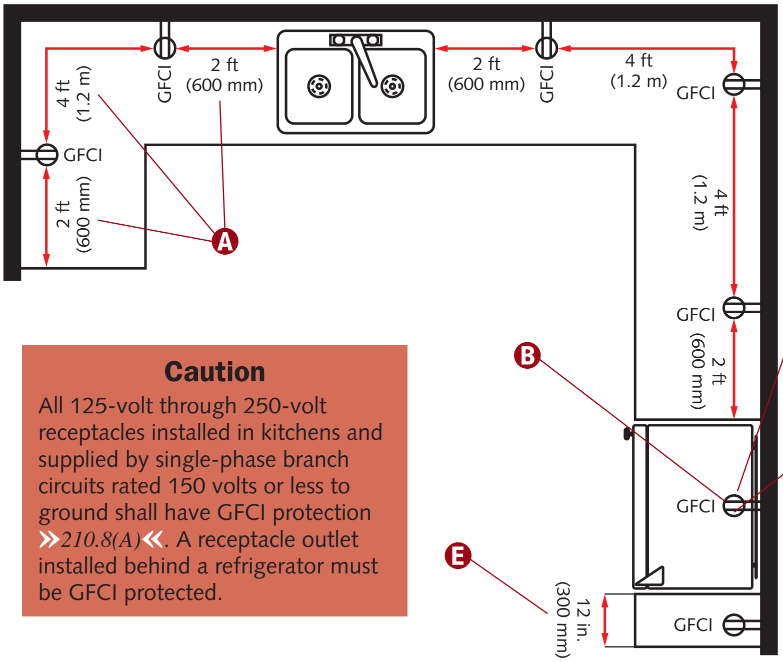
A The maximum distance to any receptacle along the wall line measured horizontally is 24 in. (600 mm) »*210.52(C)(1)*«.

B A receptacle installed for the refrigerator may be fed from one of the 20-ampere small-appliance branch circuits, or from an individual branch circuit rated 15 amperes or greater »*210.52(B)(1) Exception No. 2*«.

C Receptacles installed in kitchens of dwelling units must be GFCI protected. There are very limited exceptions in 210.8(A).

D A receptacle installed behind a refrigerator does not count as a required countertop receptacle »*210.52(C)(3)*«.

E Each wall countertop and work surface that is 12 in. (300 mm) or wider requires a receptacle »*210.52(C)*«.



Caution

All 125-volt through 250-volt receptacles installed in kitchens and supplied by single-phase branch circuits rated 150 volts or less to ground shall have GFCI protection »*210.8(A)*«. A receptacle outlet installed behind a refrigerator must be GFCI protected.

Kitchen Countertop Receptacles

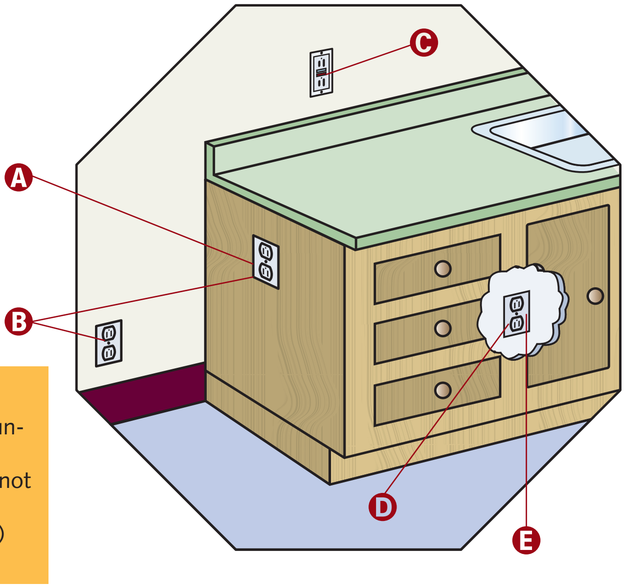
A Required receptacle outlets used to serve kitchen countertops must be located (1) on or above but not more than 20 in. (500 mm) above a countertop or work surface, (2) In a countertop using receptacle outlet assemblies listed for use in countertops, or (3) In a work surface using receptacle outlet assemblies listed for use in work surfaces or listed for use in countertops »*210.52(C)(3)*«.

B GFCI protection is required for receptacles installed along the wall to meet 210.52(A) requirements.

C GFCI protection is required for receptacles installed to serve kitchen countertops »*210.8(A)(6)*«.

D Receptacles located inside cabinets or cupboards, which do not serve kitchen countertop surfaces, require GFCI protection »*210.8(A)(6)* and *210.8(D)(7)*«.

E Receptacles located inside cabinets or cupboards do not count as required kitchen countertop receptacles »*210.52*«.



Note

Receptacle outlets are permitted to be installed in countertops or work surfaces but only if the outlet assemblies are listed for installation in countertops or work surfaces »***210.52(C)(3)(2)* and *(3)***«.

Warning

Receptacles installed for countertop and work surfaces as specified in 210.52(C) shall not be considered as the receptacles required by 210.52(A) »*210.52(A)(4)*«.

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Peninsular and Island Receptacle Placement

Receptacle outlets, if installed to serve an island or peninsular countertop or work surface, shall be installed in accordance with 210.52(C)(3). If a receptacle outlet is not provided to serve an island or peninsular countertop work surface, provisions shall be provided at the island or peninsula for future addition of a receptacle outlet to serve the island or peninsular countertop or work surface. »*210.52(C)(2)*«.

A If a receptacle outlet is installed to serve an island or peninsular countertop, the receptacle must be installed (1) on or above, but not more than 20 in. (500 mm) above a countertop or work surface, (2) in a countertop using receptacle outlet assemblies listed for use in countertops, or (3) in a work surface using receptacle outlet assemblies listed for use in work surfaces or listed for use in countertops »*210.52(C)(2)* and *210.52(C)(3)*«.

B Although this receptacle outlet has not been installed to serve a countertop surface, GFCI protection must still be provided »*210.8(A)(6)*«.

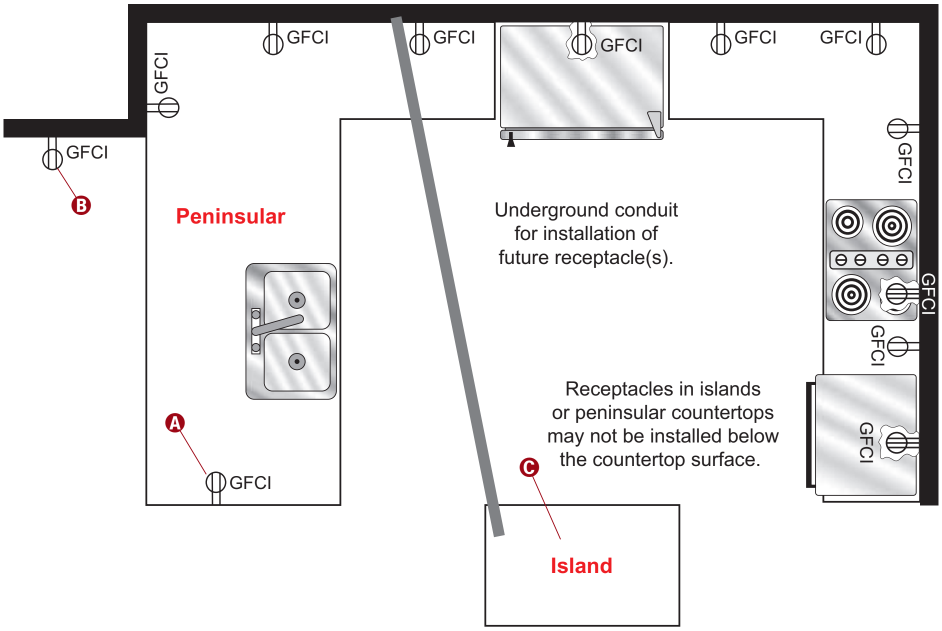
C Since no receptacle outlet has been installed at this island, provisions must be provided to install a receptacle in the future »*210.52(C)(2)*«.

Note

All 125-volt through 250-volt receptacles installed in kitchens and supplied by single-phase branch circuits rated 150 volts or less to ground shall have GFCI protection ***»210.8(A)«***.

Caution

Receptacle outlets for ranges, refrigerators, and all other appliances meeting the parameters in 210.8(A) must be GFCI protected. There are very few exceptions to this rule.


GFCI
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B
Peninsular
Underground conduit for installation of future receptacle(s).
Receptacles in islands or peninsular countertops may not be installed below the countertop surface.
A
C
Island

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Permanently Connected Appliances

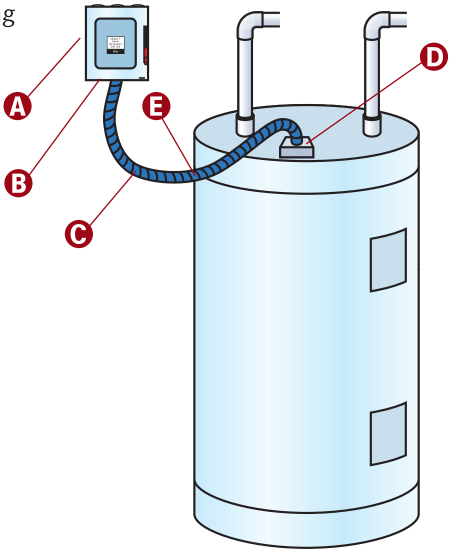
A For permanently connected appliances rated over 300 volt-amperes, a disconnecting means is not required if the branch-circuit switch or circuit breaker is within sight from the appliance or is lockable in accordance with 110.25 »*422.31(B)*«.

B A disconnecting means is not required if the branch-circuit switch or circuit breaker can be locked in the open (off) position. The provision for locking or adding a lock to the disconnecting means must be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed »*422.31(B)* and *110.25*«.

C As a general rule, water heaters shall not be connected with flexible cords »*422.16(A)*«.

D Grounding must meet 250.134 requirements for equipment fastened in place or connected by permanent wiring methods.

E Adequately protect conductors where subject to physical damage »*300.4*«.



Note

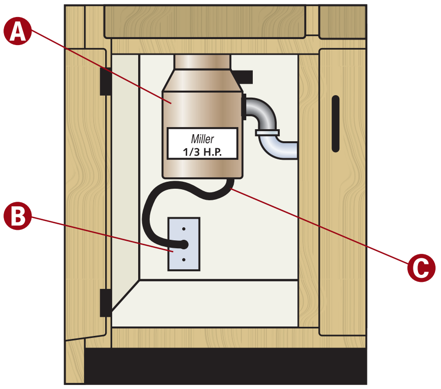
A means must be provided to simultaneously disconnect all ungrounded (hot) conductors from the appliance **»*422.30*«**.

A fastened-in-place appliance (dishwasher, in-sink waste disposer, etc.) shall not be connected to a small-appliance branch circuit »*210.52(B)(2)*«.

A A permanently connected appliance must have a means to simultaneously disconnect all ungrounded (hot) conductors from the appliance »*422.30*«.

B The disconnecting means for motor-operated appliances rated over ⅛ horsepower shall comply with 430.109 and 430.110. For permanently connected motor-operated appliances with motors rated over ⅛ horsepower, the disconnecting means shall be within sight from the appliance or be capable of being locked in the open position in compliance with 110.25 »*422.31(C)*«.

C Grounding must meet 250.134 requirements for equipment fastened in place or connected by permanent wiring methods.



Kitchen In-Sink Waste Disposers

Some appliances (dishwashers, trash compactors, and in-sink waste disposers) can be cord-and-plug-(or attachment fitting -) connected if accessible. The attachment fitting shall be a factory-installed part of the appliance and suitable for disconnection of the appliance. This arrangement provides a means of disconnect where accessible »*422.33(A)*«.

Electrically operated in-sink waste disposers can be cord and plug connected under certain conditions »*422.16(B)(1)*«. The flexible cord must be identified as suitable in the manufacturer's installation instructions and must meet *all* of the following conditions:

- The flexible cord shall have an equipment grounding conductor and be terminated with a grounding-type attachment plug. A listed appliance distinctly marked to identify it as protected by a system of double insulation shall not require termination with a grounding-type attachment plug.
- The cord must be between 18 and 36 in. (450 and 900 mm) in length.
- The receptacle must be located so the flexible cord does not become damaged.
- The receptacle shall be accessible.

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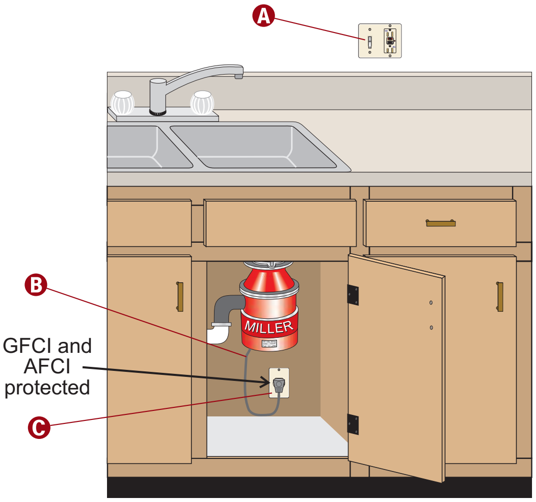
Caution

This receptacle being located within a cabinet does not eliminate the requirement for AFCI or GFCI protection.

Ⓐ The switch controlling an in-sink waste disposer serves as a disconnecting means. Also see 430.109(C).

Ⓑ Grounding must meet 250.138 requirements for cord-and plug-connected equipment.

Ⓒ Receptacles installed in kitchens shall be AFCI and GFCI protected »*210.8(A)(6)* and *210.12(B)*«.



Built-In Dishwashers and Trash Compactors

Built-in dishwashers and trash compactors can be cord-and-plug-connected under certain conditions »*422.16(B)(2)*«. The flexible cord must be identified as suitable for the purpose by the appliance manufacturer's installation instructions and must meet *all* of the following conditions:

- The flexible cord shall have an equipment grounding conductor and be terminated with a grounding-type attachment plug. A listed appliance distinctly marked to identify it as protected by a system of double insulation shall not require termination with a grounding-type attachment plug.
- The receptacle must be located so the flexible cord does not become damaged.
- The receptacle for a trash compactor shall be located in the space occupied by the appliance or adjacent thereto.
- The receptacle for a built-in dishwasher shall be located in the space adjacent to the space occupied by the dishwasher.
- The receptacle shall be accessible.

Warning

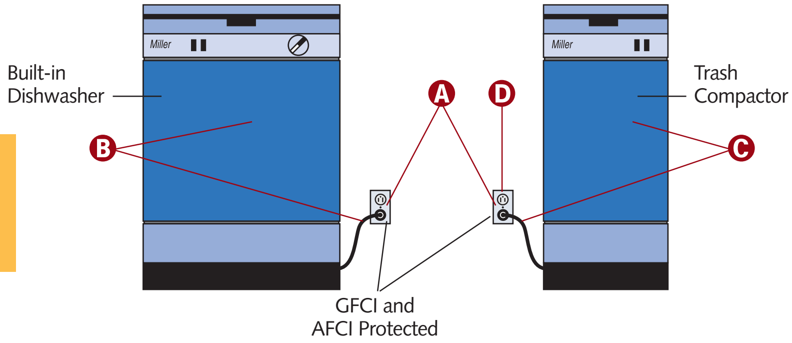
Dishwashers rated 150 volts or less to ground and 60 amperes or less, single- or 3-phase, shall be provided with GFCI protection for personnel »*210.8(D)(7)*«.

Ⓐ Where accessible, cord and plug arrangements may serve as a disconnecting means »*422.33(A)*«. A receptacle installed under the sink (inside the cabinet) may serve as a means of disconnect.

Ⓑ For a built-in dishwasher, the length of the cord shall be 3 ft to 6.5 ft (0.9 m to 2.0 m) measured from the face of the attachment plug to the plane of the rear of the appliance »*422.16(B)(2)(2)*«.

Ⓒ For a trash compactor, the length of the cord shall be 3 ft to 4 ft (0.9 m to 1.2 m) measured from the face of the attachment plug to the plane of the rear of the appliance »*422.16(B)(2)(1)*«.

Ⓓ Receptacles in kitchens must be AFCI and GFCI protected »*210.8(A)(6)* and *210.12(B)*«.



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Appliance Branch-Circuit Rating

Branch circuits, rated 15 or 20 amperes, may feed lighting units, utilization equipment, or a combination of both. The rating of any one cord- and plug-connected utilization equipment not fastened in place shall not exceed 80% of the branch-circuit ampere rating »*210.23(B)*«. Cord- and plug-connected equipment may be portable or may be fastened-in-place equipment. Fastened-in-place utilization equipment shall not exceed 50% of the branch-circuit ampere rating where the circuit also feeds lighting units or non-fastened-in-place utilization equipment »*210.23(B)(2)*«.

Ⓐ The full-load current for a single-phase motor is found in Table 430.248.

Note

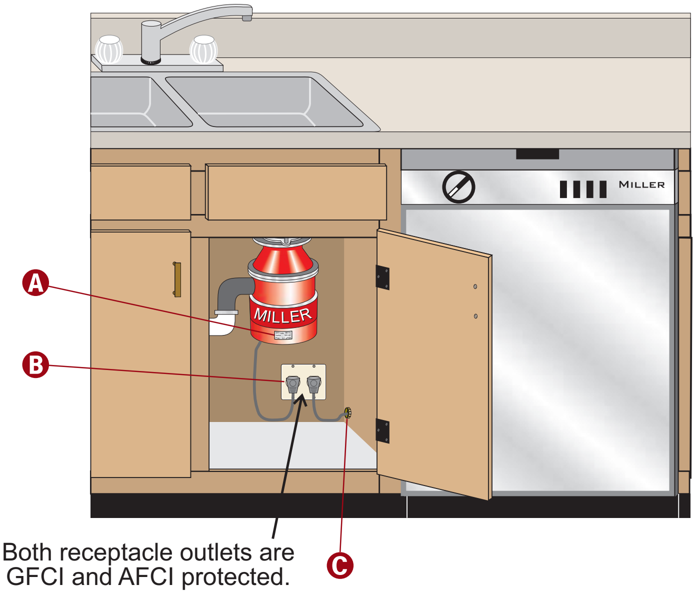
Many jurisdictions require dedicated branch circuits for dishwashers and in-sink waste disposers.

Caution

GFCI protection shall be provided for outlets that supply dishwashers »*210.8(D)(7)*«. GFCI protection is required for receptacles installed in kitchens »*210.8(A)(6)*«. Passing through a cabinet door or doorway does not eliminate the requirement for AFCI or GFCI protection.

Ⓑ The total load shall not exceed the branch-circuit rating »*220.11*«. For motor-operated, fastened-in-place appliances with a motor larger than ⅛ horsepower, multiply the largest motor by 125% and add 100% of the other loads »*220.11(A)* and *430.22*«.

Ⓒ Where the flexible cord passes through an opening, it shall be protected against damage by a bushing, grommet, smoothed edge, or other approved means »*422.16(B)(2)(5)*«.



Both receptacle outlets are GFCI and AFCI protected.

Calculation for One Counter-Mounted Cooking Unit (Cooktop)

Branch-circuit calculation for one cooktop with a nameplate rating of 6.5 kW at 240 volts:

- Use the nameplate rating to determine the branch-circuit conductor size and the overcurrent protection for one counter-mounted cooking unit »*Table 220.55, Note 5*«
- 6.5 kW = 6500 watts

  6500 watts ÷ 240 = 27.1 amperes
- Overcurrent protective device = 30 amperes »*240.4(B)*«
- Conductor size = 10 AWG copper »*Table 310.16* and *240.4(D)*«

Calculation for One Wall-Mounted Oven

Branch-circuit calculation for one oven with a nameplate rating of 4 kW at 240 volts:

- Use the nameplate rating to determine the branch-circuit conductor size and the overcurrent protection for one wall-mounted oven »*Table 220.55, Note 5*«
- 4 kW = 4000 watts

  4000 watts ÷ 240 = 16.7 amperes
- Overcurrent protective device = 20 amperes »*240.4(B)*«
- Conductor size = 12 AWG copper »*Table 310.16* and *240.4(D)*«

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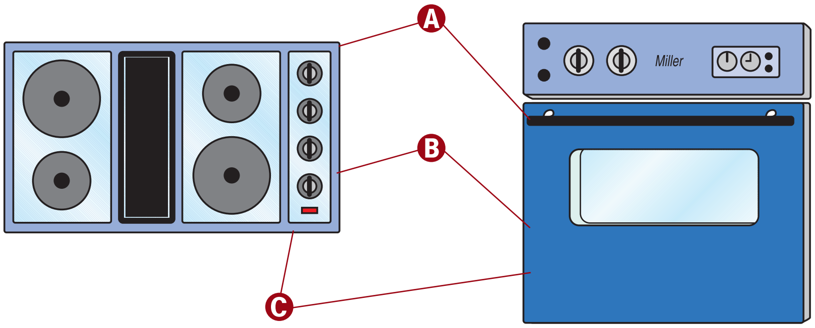
Counter-Mounted Cooking Units (Cooktops) and Wall-Mounted Ovens

Ⓐ The nameplate rating of a counter-mounted cooking unit or a wall oven shall be the minimum branch-circuit load »*Table 220.55, Note 5*«.

Ⓑ Wall-mounted ovens and counter-mounted cooking units may be connected permanently or by cord and plug »*422.16(B)(3)*«.

Ⓒ A disconnecting means is required »*422.30*«.



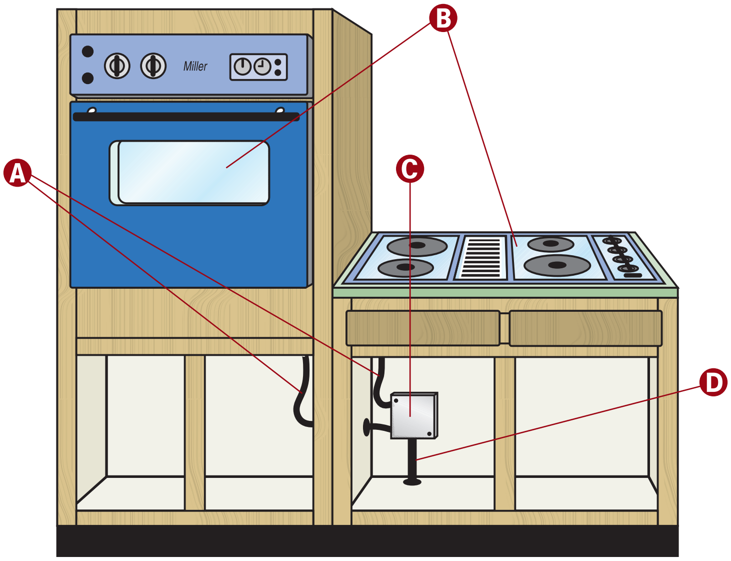
Cooktop and Wall-Mounted Oven(s) on Same Branch Circuit

Ⓐ Tap conductors from a 50-ampere branch circuit must have an ampacity of at least 20 and not less than the ampacity of the individual unit served. These tap conductors include any conductors that are part of the pigtail supplied with the appliance that are smaller than the branch-circuit conductors. The taps shall not be longer than necessary for servicing the appliance »*210.19(C) Exception No. 1*«.

Ⓑ Where a single branch circuit feeds one cooktop and one or two ovens (in the same room), add the nameplate ratings of the appliances, treating the total kW as one range to be found in Table 220.55 »*Table 220.55, Note 6*«.

Ⓒ No disconnecting means is required if the branch-circuit switch or circuit breaker can be locked in the open (off) position in accordance with 110.25 »*422.31(B)*«.

Ⓓ It is permissible to feed one cooktop and one or two wall-mounted ovens with one branch circuit where all of the units are in the same room »*Table 220.55, Note 6*«.

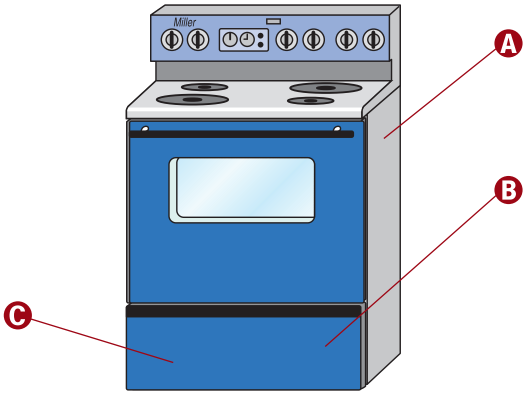


Electric Ranges

Ⓐ Frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and outlet or junction boxes that are part of the circuit for these appliances shall be connected to the equipment grounding conductor in accordance with 250.140(A) or the grounded conductor in accordance with 250.140(B) »*250.140*«.

Ⓑ It is permissible to compute the branch-circuit load for one range in accordance with Table 220.55 »*Table 220.55, Note 4*«.

Ⓒ A disconnecting means is required »*422.30*«. An accessible separable connector or an accessible plug (or attachment fitting) and receptacle can serve as the disconnecting means »*422.33(A)*«.



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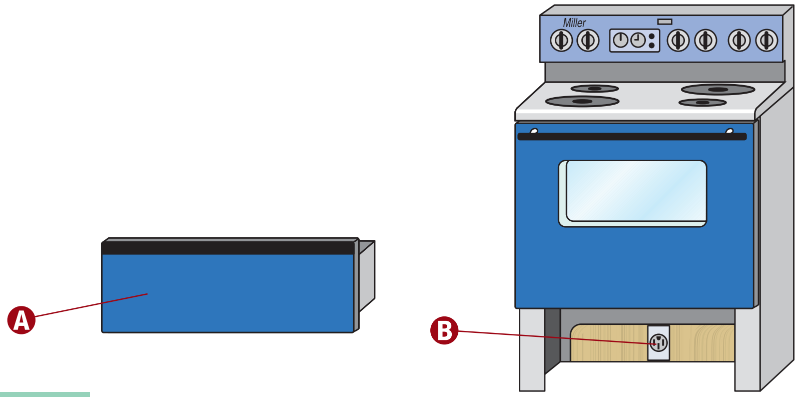
Note

For existing branch-circuit installations only where an equipment grounding conductor is not present in the outlet or junction box, the frames of electric ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and outlet or junction boxes that are part of the circuit for these appliances shall be permitted to be connected to the grounded circuit conductor if all the following conditions are met: (1) The supply circuit is 120/240-volt, single-phase, 3-wire or 208Y/120-volt derived from a 3-phase, 4-wire, wye-connected system; (2) the grounded conductor is not smaller than 10 AWG copper or 8 AWG aluminum or copper-clad aluminum; and (3) grounding contacts of receptacles furnished as part of the equipment are bonded to the equipment. In addition to these three conditions, the grounded conductor must be (1) insulated or if uninsulated be part of a Type SE cable and the branch circuit originates at the service or (2) part of a Type SE cable that originates in equipment other than a service and be insulated or field covered within the supply enclosure with listed insulating material, such as tape or sleeving, to prevent contact of the uninsulated conductor with any normally non-current-carrying metal parts ***»250.140(B)«***.

Ⓐ Most household electric ranges are cord and plug connected. The attachment plug and receptacle can serve as the disconnecting means if they are accessible by removing a drawer on the front of the range *»422.33(B)«*.

Ⓑ New branch-circuit conductors installed for a range must have an insulated grounded (neutral) conductor and a grounding means. Grounding must meet 250.138 requirements for cord- and plug-connected equipment.



Note

The neutral conductor for a household electric range, a wall-mounted oven, or a counter-mounted cooking unit shall not be smaller than 10 AWG copper ***»210.19(C) Exception No. 2«***.

Calculation for Ranges Rated 8¾ kW through 12 kW

Branch-circuit calculation for one range with a nameplate rating of 12 kW at 240 volts:

- Compute the branch-circuit load for one range in accordance with Table 220.55.
- 12 kW = 8 kW (Column C)

  8 kW = 8000 watts

  8000 watts ÷ 240 = 33.3 amperes
- Overcurrent protective device = 40 amperes *»210.19(C)«*
- Conductor size = 8 AWG *»Table 310.16«*

Note

The minimum branch-circuit rating for a range rated 8¾ kW or more is 40 amperes ***»210.19(C)«***.

Calculation for Ranges Rated More than 12 kW

Branch-circuit calculation for one range with a nameplate rating of 15 kW at 240 volts:

- Compute the branch-circuit load for one range in accordance with Table 220.55.
- Column C is for 12 kW and under ranges; Note 1 applies to ranges over 12 kW
- First, subtract 12 kW from the 15-kW range:

  15 kW − 12 kW = 3 kW
- Next, multiply 3 kW by 5% = 15%
- Then, multiply 8 kW (Column A) by 15%:

  8 kW × 15% = 1.2 kW
- Finally, add 1.2 kW to 8 kW:

  1.2 kW + 8 kW = 9.2 kW = 9200 watts
- 9200 watts ÷ 240 volts = 38.3 amperes
- Overcurrent protective device = 40 amperes *»240.4(B)«*
- Conductor size = 8 AWG *»Table 310.16«*

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Kitchen, Dining Room, and Breakfast Room

A A minimum of two small-appliance branch circuits are required for receptacles serving kitchen countertops »*210.52(B)(3)*«. Either or both of these small-appliance branch circuits may feed other receptacles in the kitchen, pantry, breakfast room, or dining room.

B Noncountertop receptacle placement is determined by wall space »*210.52(A)*«.

C A receptacle outlet installed to serve a specific appliance (such as a refrigerator) can be supplied from an individual branch circuit rated 15 amperes or greater »*210.52(B)(1) Exception No. 2*«.

D Range hoods and lights are not permitted on small-appliance branch circuits »*210.52(B)(2)*«.

E All wall and floor receptacle outlets covered by 210.52(A) and all countertop outlets covered by 210.52(C) in the kitchen, pantry, breakfast room, dining room, or similar area shall be supplied from 20-ampere branch circuits (except for refrigeration equipment) »*210.52(B)(1)*«.

F A minimum of two circuits is required for receptacles located in the kitchen, pantry, breakfast room, dining room, or similar areas »*210.52(B)(1)*«.

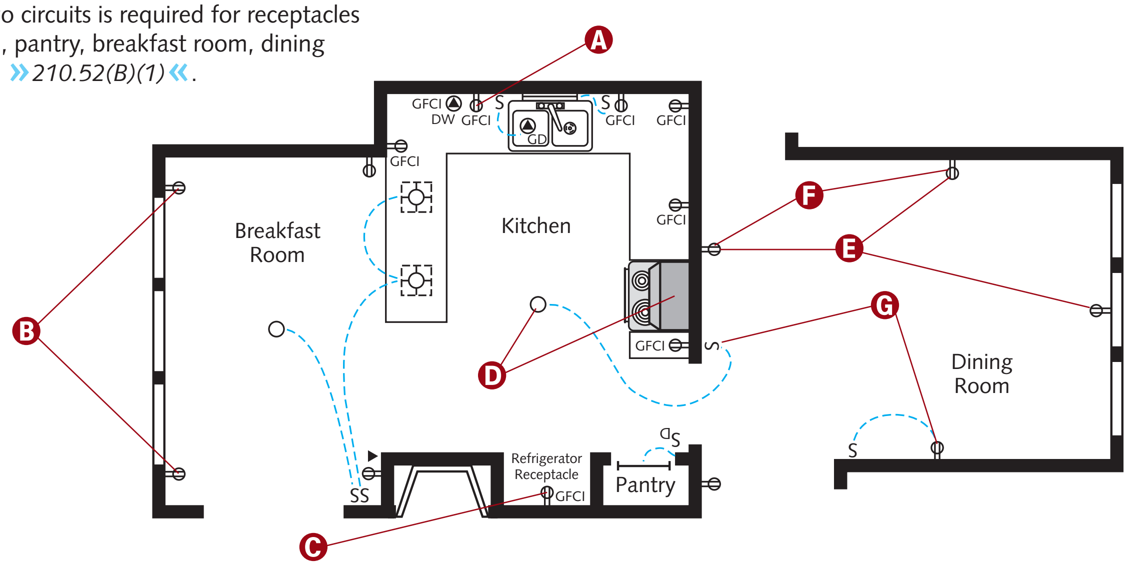
G At least one wall switch-controlled lighting outlet shall be installed in dining rooms, kitchens, and breakfast rooms »*210.70(A)(1)*«. One or more receptacles controlled by a wall switch are permitted in lieu of a lighting outlet in dining rooms and breakfast rooms, but not in kitchens »*210.70(A)(1) Exception No. 1*«.

Note

All 120-volt, single-phase, 10-, 15, and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar areas shall be arc-fault circuit-interrupter (AFCI) protected by any of the means described in 210.12(A)(1) through (6) »***210.12(B)***«.

Note

Switches or other control devices for lighting outlets shall not rely exclusively on a battery unless a means is provided for automatically energizing the lighting outlets upon battery failure »***210.70***«.

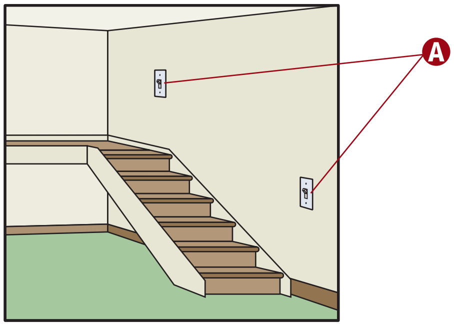


Hallways and Stairways

Hallway and Stairway Lighting

A minimum of one lighting outlet is required in each hallway and stairway »*210.70(A)(2)(1)*«. The light must be wall switch–controlled, except where controlled by remote, central, or automatic means »*210.70(A)(2)(3) Exception*«. A receptacle controlled by a wall switch is not permitted.

A Interior stairways of six or more risers (steps) shall have a wall switch located at each floor level and landing level that includes stairway entry »*210.70(A)(2)(3)*«.



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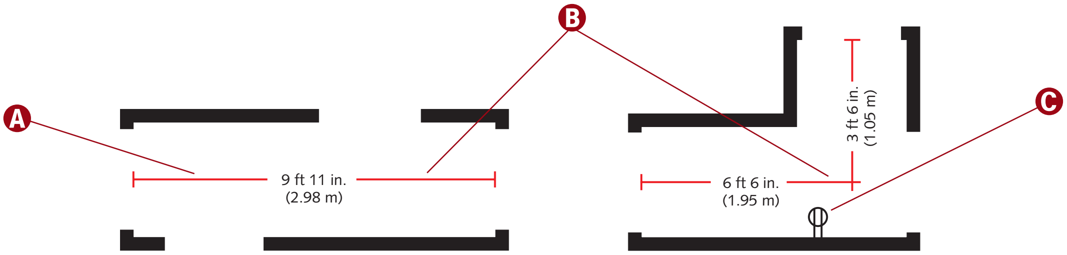
Hallway Receptacle Placement

Receptacles in hallways are not subject to the general provisions for placement determined by wall space.

A If length is less than 10 ft (3.0 m), no receptacle is required.

B Hallways measuring 10 ft (3.0 m) or more in length must have at least one receptacle outlet »*210.52(H)*«. Hallway length is determined by measuring along the hallway centerline, without passing through a doorway.

C If length is 10 ft (3.0 m) or more, a receptacle is required.



Caution

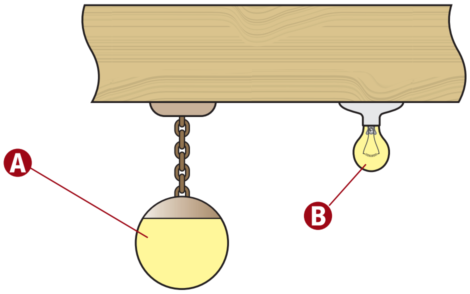
Foyers that are not part of a hallway in accordance with 210.52(H) and that have an area that is greater than 60 ft^2 (5.6 m^2) shall have a receptacle(s) located in each wall space 3 ft (900 mm) or more in width. Doorways, door-side windows that extend to the floor, and similar openings shall not be considered wall space »*210.52(I)*«

Clothes Closets

Luminaire Types *Not* Permitted in Clothes Closets »*410.16(C)*«

A Pendant luminaires or lampholders

B Incandescent luminaires with open or partially enclosed lamps



Note

The clothes closet storage space shall be the volume bounded by the sides and back closet walls and planes extending from the closet floor vertically to a height of 6 ft (1.8 m) or to the highest clothes-hanging rod and parallel to the walls at a horizontal distance of 24 in. (600 mm) from the sides and back of the closet walls, respectively. The volume extends vertically to the closet ceiling parallel to the walls at a horizontal distance of 12 in. (300 mm) or the width of the shelf, whichever is greater. For a closet that permits access to both sides of a hanging rod, this space includes the volume below the highest rod extending 12 in. (300 mm) on either side of the rod on a plane horizontal to the floor extending the entire length of the rod »*410.16(A)*«. For an illustrated view of this definition, see "Dedicated Space in Clothes Closets."

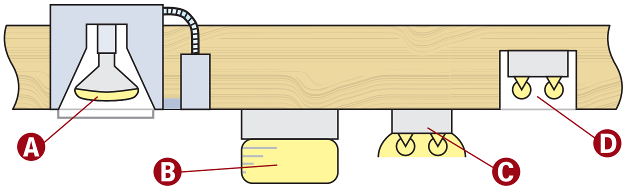
Luminaire Types Permitted in Clothes Closets »*410.16(B)*«

A Recessed incandescent or light-emitting diode (LED) luminaire with a completely enclosed light source

B Surface-mounted incandescent or LED luminaire with a completely enclosed light source

C Surface-mounted fluorescent luminaire

D Recessed fluorescent luminaire



Note

Also permitted in clothes closets are surface-mounted fluorescent or light-emitting diode (LED) luminaires that are identified as suitable for installation within the closet storage space »*410.16(B)(3)*«.

Note

All luminaires, lampholders, and retrofit kits shall be listed »*410.6*«.

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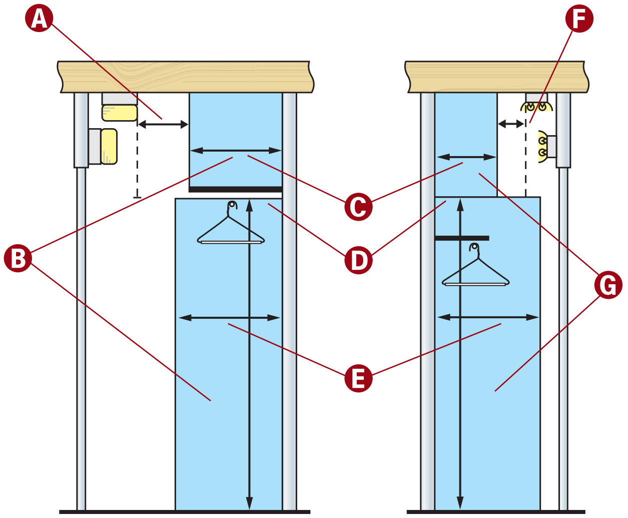
Dedicated Space in Clothes Closets

Receptacles in clothes closets are permitted, but are not required.

Lighting outlets are permitted in closets, but are not required.



A Surface-mounted incandescent or LED luminaires with a completely enclosed light source shall have a minimum 12-in. (300-mm) clearance between the luminaire and the nearest point of a closet storage space »*410.16(D)(1)*«.

B The blue shading represents closet storage space.

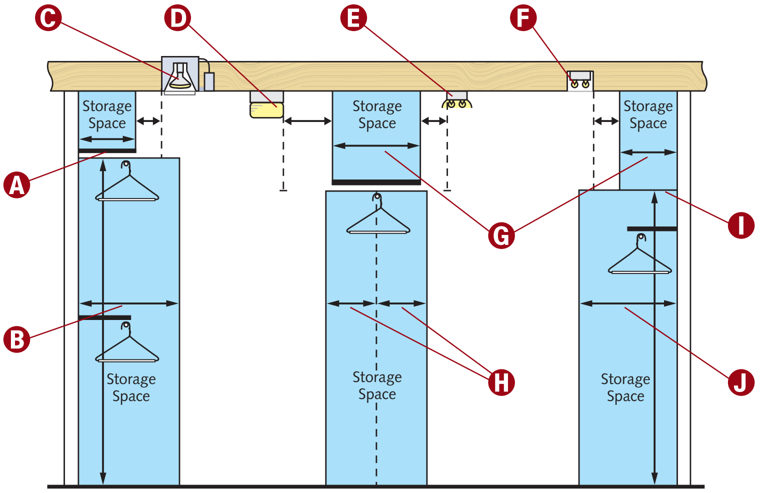
C The depth of the closet storage space above either 6 ft (1.8 m) or to the highest clothes-hanging rod is 12 in. (300 mm) or the width of the shelf, whichever is greater »*410.16(A) Clothes Closet Storage Space*«.

D The closet storage space extends up from the floor to a height of 6 ft (1.8 m) or to the highest clothes-hanging rod »*410.16(A) Clothes Closet Storage Space*«.

E The depth of the closet storage space is 24 in. (600 mm) »*410.16(A)*«.

F Surface-mounted fluorescent luminaires shall have a minimum 6-in. (150-mm) clearance between the luminaire and the nearest point of a closet storage space »*410.16(D)(2)*«.

G The blue shading represents closet storage space.



A The closet storage space extends up from the floor to a height of 6 ft (1.8 m) or to the highest clothes-hanging rod »*410.16(A)*«.

B The depth of the closet storage space is 24 in. (600 mm) »*410.16(A)*«.

C Recessed incandescent or LED luminaires with a completely enclosed light source shall have a minimum 6-in. (150-mm) clearance between the luminaire and the nearest point of a storage space »*410.16(D)(3)*«.

D Surface-mounted incandescent or LED luminaires with a completely enclosed light source shall have a minimum 12-in. (300-mm) clearance between the luminaire and the nearest point of a storage space »*410.16(D)(1)*«.

E Surface-mounted fluorescent luminaires shall have a minimum 6-in. (150-mm) clearance between the luminaire and the nearest point of a storage space »*410.16(D)(2)*«.

F Recessed fluorescent luminaires shall have a minimum 6-in. (150-mm) clearance between the luminaire and the nearest point of a storage space »*410.16(D)(4)*«.

G The depth of the closet storage space above either 6 ft (1.8 m) or to the highest clothes-hanging rod is 12 in. (300 mm) or the width of the shelf, whichever is greater »*410.16(A)*«.

H For a closet with access to both sides of a hanging rod, the storage space shall include the volume below the highest rod extending 12 in. (300 mm) on either side of the rod on a plane horizontal to the floor and extending the entire length of the rod »*410.16(A)*«.

I The closet storage space extends up from the floor to a height of 6 ft (1.8 m) or to the highest clothes-hanging rod »*410.16(A)*«.

J The depth of the closet storage space is 24 in. (600 mm) »*410.16(A)*«.

Note

Surface-mounted fluorescent or LED luminaires shall be permitted to be installed within the closet storage space where identified for this use »***410.16(D) Exception***«.

Caution

Overcurrent protective devices shall not be located in the vicinity of easily ignitible material, such as in clothes closets »*240.24(D)*«.

Bathrooms

Bathroom Area

The general provisions for receptacle placement by wall space do not apply to bathrooms.

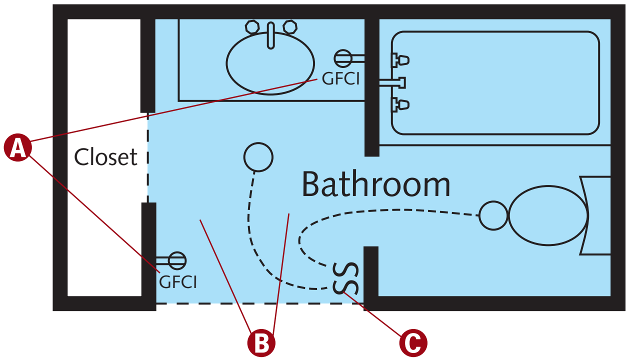
Ⓐ All 125-volt through 250-volt receptacles installed in the locations specified in 210.8(A)(1) through (A)(12) and supplied by single-phase branch circuits rated 150 volts or less to ground shall have ground-fault circuit-interrupter protection for personnel »*210.8(A)*«. Bathrooms are listed in 210.8(A)(1).

Ⓑ **Bathroom Definition:** An area including a basin sink (basin) with one or more of the following: a toilet, a urinal, a tub, a shower, a bidet, or similar plumbing fixtures »*Article 100—Definitions*«. A bathroom is an **area** and not necessarily a single room.

Ⓒ One or more lighting outlets controlled by a wall switch are required in bathrooms »*210.70(A)(1)*«.

Note

Service disconnecting means shall not be located in bathrooms »***230.70(A)(2)***«. Overcurrent protective devices, other than supplementary overcurrent protection, shall not be installed in bathrooms »***240.24(E)***«. Supplementary overcurrent protection is not branch-circuit overcurrent protection. It is an additional overcurrent protection usually installed within luminaires, appliances, and other equipment. It is not required that supplementary overcurrent protection be readily accessible »***240.10***«.

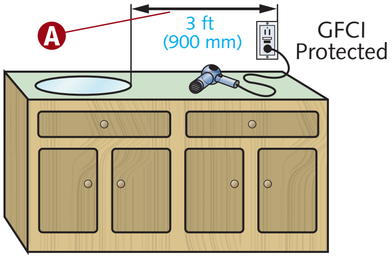


Receptacle within 36 in. (900 mm) of Sink

Ⓐ At least one receptacle shall be located within 3 ft (900 mm) of the outside edge of each basin (lavatory or sink) »*210.52(D)*«.

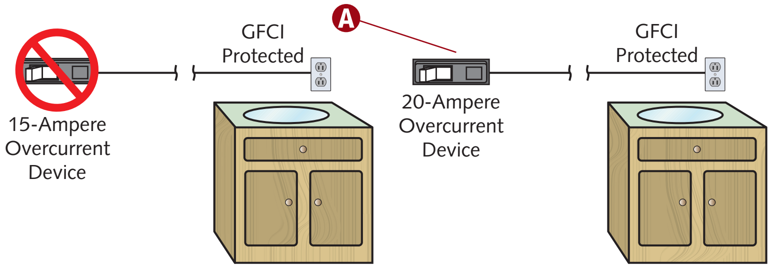
Note

In no case shall the receptacle be located more than 12 in. (300 mm) below the top of the basin or basin countertop »***210.52(D)***«.



Bathroom Branch-Circuit Rating

Ⓐ Bathroom receptacle outlets shall be supplied by at least one 120-volt, 20-ampere branch circuit »*210.11(C)(3)*«.



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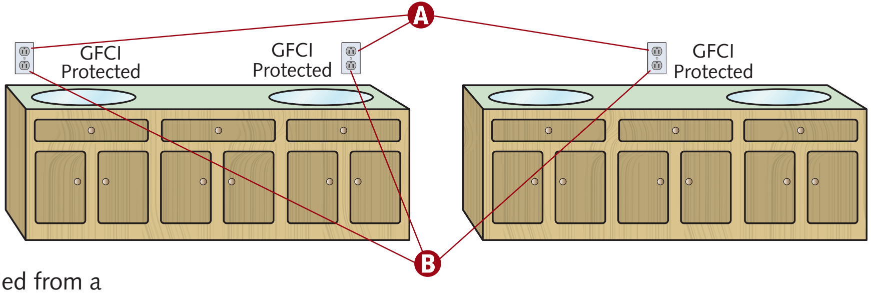
Bathroom Receptacles

Receptacles, unless listed as receptacle assemblies for installation in countertop or work surface applications, shall not be installed in a face-up position in countertops, work surfaces, or in the area below a sink »*406.5(E)* and *(G)*«.

A At least one receptacle shall be located within 36 in. (900 mm) of the outside edge of each sink »*210.52(D)*«.

B Receptacles may have an individual rating of either 15 or 20 amperes, but must be supplied from a 20-ampere branch circuit »*210.11(C)(3)*«. GFCI protection for personnel is required for all bathroom receptacles. The ground-fault circuit interrupter must be installed in a readily accessible location »*210.8(A)(1)*«.


A
GFCI Protected
GFCI Protected
GFCI Protected
B

Note

Receptacle outlet assemblies listed for use in countertops shall be permitted to be installed in the countertop »***210.52(D)***«.

Caution

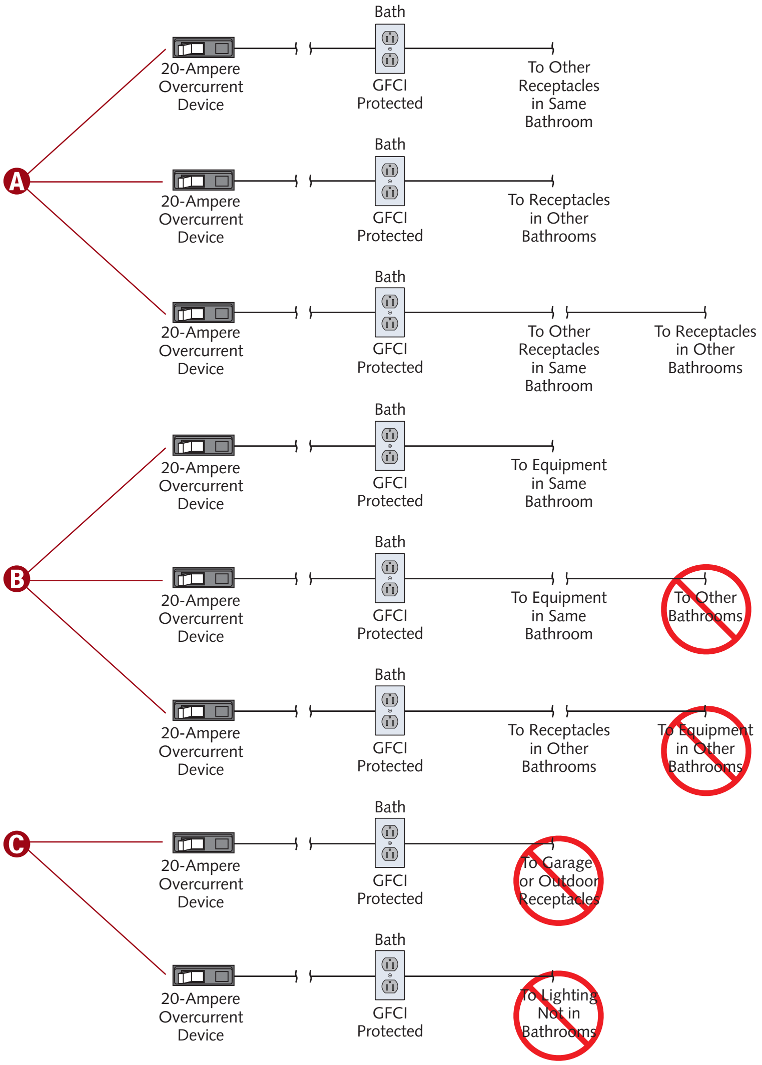
The receptacle outlet shall be located on a wall or partition that is adjacent to the sink or sink countertop, located on the countertop, or installed on the side or face of the sink cabinet. In no case shall the receptacle be located more than 12 in. (300 mm) below the top of the sink or sink countertop »*210.52(D)*«.

Bathroom

A A branch circuit providing power to a bathroom receptacle may also provide power to other bathroom receptacles, whether in the same bathroom or in different bathrooms »*210.11(C)(3)*«.

B A branch circuit providing power to a bathroom receptacle may also provide power to other equipment, such as lighting and exhaust fans, but only within the same bathroom »*210.11(C)(3) Exception*«. If the branch circuit provides power to a bathroom receptacle and other equipment, the circuit shall not provide power to any other bathroom.

C A branch circuit providing power to bathroom receptacles shall not provide power to any receptacle or lighting outside of bathrooms »*210.11(C)(3)*«.


A
20-Ampere Overcurrent Device
Bath
GFCI Protected
To Other Receptacles in Same Bathroom
20-Ampere Overcurrent Device
Bath
GFCI Protected
To Receptacles in Other Bathrooms
20-Ampere Overcurrent Device
Bath
GFCI Protected
To Other Receptacles in Same Bathroom
To Receptacles in Other Bathrooms
B
20-Ampere Overcurrent Device
Bath
GFCI Protected
To Equipment in Same Bathroom
20-Ampere Overcurrent Device
Bath
GFCI Protected
To Equipment in Same Bathroom
To Other Bathrooms
20-Ampere Overcurrent Device
Bath
GFCI Protected
To Receptacles in Other Bathrooms
To Equipment in Other Bathrooms
C
20-Ampere Overcurrent Device
Bath
GFCI Protected
To Garage or Outdoor Receptacles
20-Ampere Overcurrent Device
Bath
GFCI Protected
To Lighting Not in Bathrooms

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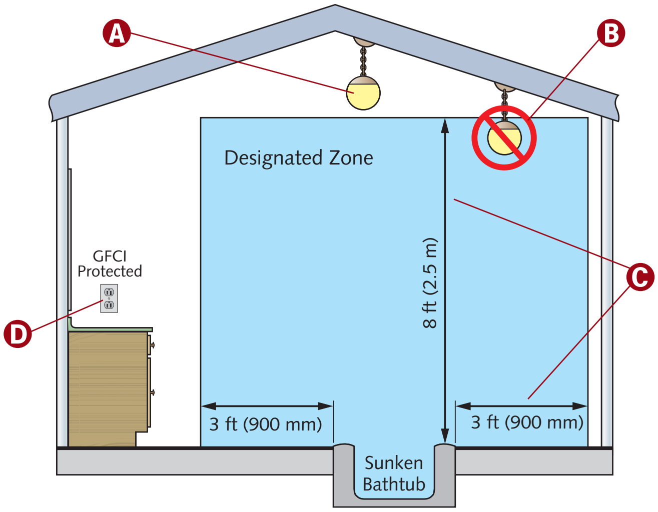
Bathtub and Shower Zone

Ⓐ Luminaire permitted (not in zone)

Ⓑ Luminaire not permitted

Ⓒ Receptacles and no parts of cord-connected luminaires, chain-, cable-, or cord-suspended luminaires, lighting track, pendants, and ceiling-suspended (paddle) fans are permitted within a certain zone of a bathtub »*410.10(D)(1)* and *406.9(C)*«. The bathtub zone measures 3 ft (900 mm) horizontally and 8 ft (2.5 m) vertically from the top of the bathtub rim or shower stall threshold and includes the space directly over the tub.

Ⓓ Unless meeting one of the exceptions in 406.9(C), receptacles are not permitted in the zone. This receptacle is permitted because it is not in the zone.



Warning

Luminaires located within the actual outside dimension of the bathtub or shower to a height of 8 ft (2.5 m) vertically from the top of the bathtub rim or shower threshold shall be marked for damp locations, or marked for wet locations where subject to shower spray »*410.10(D)(2)*«.

Note

In bathrooms with less than the required zone the receptacle(s) shall be permitted to be installed opposite the bathtub rim or shower stall threshold on the farthest wall within the room »***406.9(C) Exception No. 2***«.

Ⓐ Recessed lights, surface-mounted lights, and exhaust fans are permitted within the bathtub zone. Exposed, normally non-current-carrying metal parts must be connected to an equipment grounding conductor in accordance with 250.110.

Ⓑ Chain-, cable-, or cord-suspended luminaires, cord-connected luminaires, lighting track, pendants, and ceiling-suspended (paddle) fans, and receptacles are permitted only *outside* the zone.

Ⓒ The bathtub zone measures 3 ft (900 mm) horizontally and 8 ft (2.5 m) vertically from the top of the bathtub rim or shower stall threshold. The zone is all-encompassing and includes the space directly over the tub or shower stall »*410.10(D)(1)* and *406.9(C)*«.

Ⓓ This receptacle is permitted because it is not in the zone.

Note

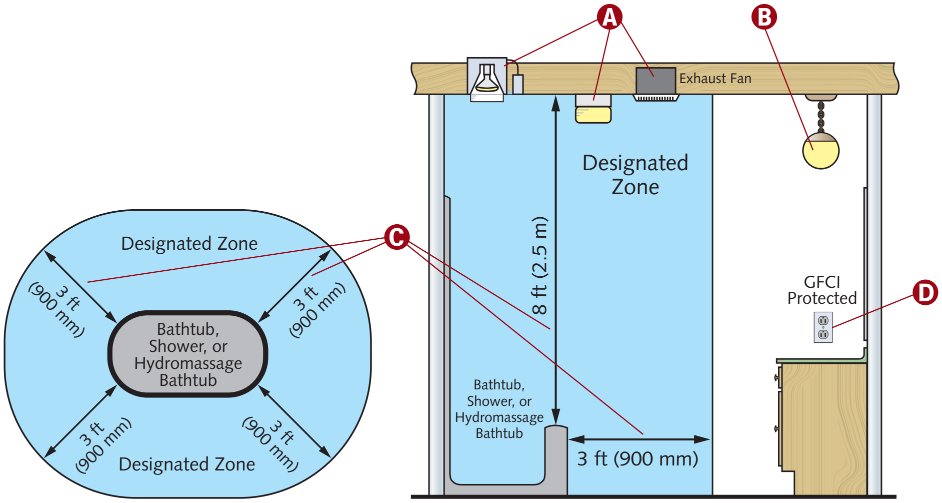
All 125-volt through 250-volt receptacles supplied by single-phase branch circuits rated 150 volts to ground or less and installed within 6 ft (1.8 m) of the outside edge of the bathtub or shower stall shall have ground-fault circuit-interrupter protection for personnel »***210.8(A)(10)***«. Since receptacles installed in bathrooms are already required to have ground-fault circuit-interrupter protection for personnel, this provision applies to bathtubs and shower stalls that are not located in bathrooms.

Note

Factory-installed receptacles that are not readily accessible and are mounted internally to bathroom exhaust fan assemblies shall not require GFCI protection unless required by the installation instructions or listing »***210.8(A) Exception No. 4***«.

All equipment that is listed, labeled, or both, or identified for a use shall be installed and used in accordance with any instructions included in the listing, labeling, or identification »***110.3(B)***«.

Some bathroom exhaust fans include the requirement for 12 AWG conductors and GFCI protection in the installation instructions. Always read any provided literature before installing electrical equipment.



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Basements and Garages

Garage Receptacles

A In each attached garage and in each detached garage with electric power, at least one receptacle outlet shall be installed in each vehicle bay and not more than 5½ ft (1.7 m) above the floor »*210.52(G)(1)*«.

B Laundry equipment receptacles shall not be counted as required garage receptacles »*210.52(G)*«. In dwelling units, at least one receptacle outlet shall be installed in areas designated for the installation of laundry equipment »*210.52(F)*«. Since this receptacle is installed in a laundry area, it must also be AFCI protected »*210.12* and *210.12(B)(13)*«.

Caution

In addition to the number of branch circuits required by other parts of 210.11, at least one 120-volt, 20-ampere branch circuit shall be installed to supply receptacle outlets in attached garages and in detached garages with electric power. This circuit shall have no other outlets other than outdoor receptacle outlets »*210.11(C)(4) and Exception No. 1*«

Note

Where the 20-ampere circuit required by 210.11(C)(4) supplies a single vehicle bay garage, outlets for other equipment within the same garage shall be permitted to be supplied in accordance with 210.23(B)(1) and (B)(2) »***210.11(C)(4) Exception No. 2***«.

Additional branch circuits rated 15 amperes or greater shall be permitted to serve receptacle outlets other than those required by 210.52(G)(1) »***210.11(C)(4)***«.

C Receptacles not readily accessible must have GFCI protection for personnel »*210.8(A)(2)*«.

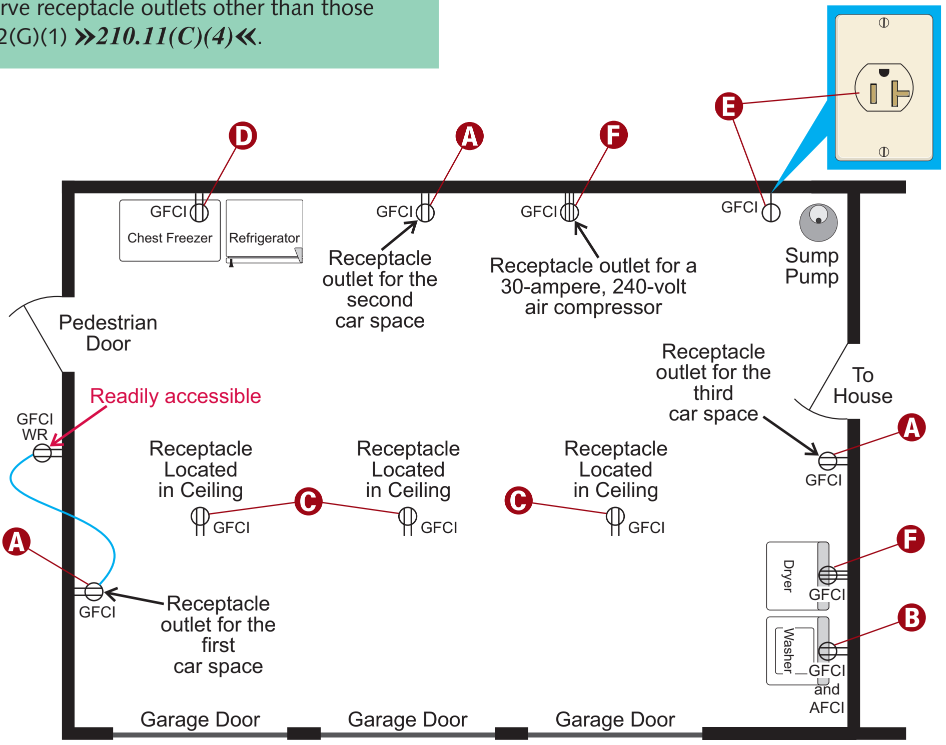
D If a duplex receptacle is installed for two appliances, GFCI protection is required »*210.8(A)(2)*«.

E A single receptacle installed on an individual 20-ampere branch circuit must have a rating of 20 amperes »*210.21(B)(1)*«.

F All 125-volt through 250-volt receptacles installed in the locations specified in 210.8(A)(1) through (A)(12) and supplied by single-phase branch circuits rated 150 volts or less to ground or less shall have ground-fault circuit-interrupter protection for personnel »*210.8(A)*«. Garages are listed in 210.8(A)(2) and laundry areas are listed in 210.8(A)(11).

Warning

All 125-volt through 250-volt receptacles installed in the locations specified in 210.8(A)(1) through (A)(12) and supplied by single-phase branch circuits rated 150 volts or less to ground shall have ground-fault circuit-interrupter protection for personnel »*210.8(A)*«. Garages are listed in 210.8(A)(2). Note, there are very limited exceptions to this rule.


D
A
F
E
GFCI
Chest Freezer
Refrigerator
GFCI
Receptacle outlet for the second car space
GFCI
Receptacle outlet for a 30-ampere, 240-volt air compressor
GFCI
Sump Pump
Pedestrian Door
Receptacle outlet for the third car space
To House
Readily accessible
GFCI WR
A
Receptacle Located in Ceiling
GFCI
C
Receptacle Located in Ceiling
GFCI
C
Receptacle Located in Ceiling
GFCI
GFCI
A
Dryer
GFCI
F
Washer
GFCI and AFCI
B
GFCI
Receptacle outlet for the first car space
Garage Door
Garage Door
Garage Door

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Lighting

A In each attached garage and in each detached garage with electric power, at least one receptacle outlet shall be installed in each vehicle bay. Do not install this receptacle outlet more than 5½ ft (1.7 m) above the floor *»210.52(G)(1)«*. At least one receptacle shall be installed in each separate unfinished portion of a basement *»210.52(G)(3)«*. (Receptacle placement is not determined by wall space.)

B At least one wall switch–controlled lighting outlet is required to provide illumination on the exterior side of an outside entrance or exit with grade-level access *»210.70(A)(2)(2)«*.

C A vehicle garage door is not considered an outside entrance or exit and therefore does not require a wall switch–controlled lighting outlet *»210.70(A)(2)(2)«*.

D A lighting outlet shall be installed at, or near, equipment that may require servicing *»210.70(C)«*.

E At least one wall switch–controlled lighting outlet is required for basements and attached garages *»210.70(A)(2)(1)* and *210.70(C)«*.

F Interior stairways with six or more steps shall have a wall switch located at each floor level and landing that includes an entryway *»210.70(A)(2)(3)«*.

G A lighting outlet installed to provide illumination for the general area (basement, garage, etc.) may also serve as the equipment lighting, provided it is located at or near the equipment.

H All 125-volt through 250-volt receptacles installed in the locations specified in 210.8(A)(1) through (A)(12) and supplied by single-phase branch circuits rated 150 volts or less to ground shall have ground-fault circuit-interrupter protection for personnel *»210.8(A)«*. Basements are listed in 210.8(A)(5).

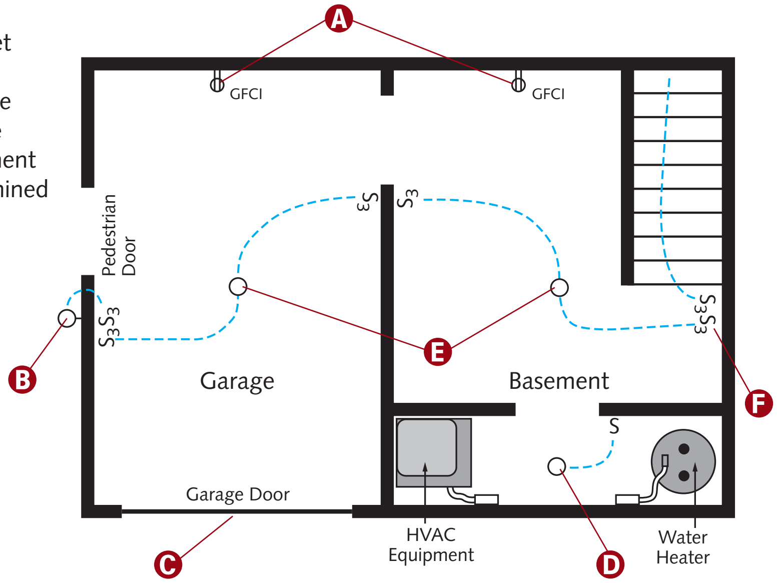
Note

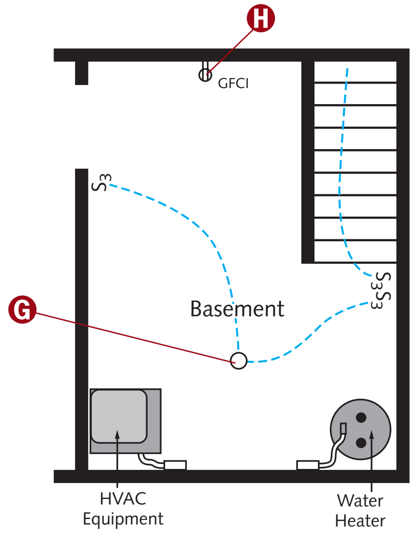
A receptacle in a basement supplying only a permanently installed premise security system shall not be required to have GFCI protection ***»210.8(A) Exception No. 2«***. Receptacles installed under this exception shall not be considered as meeting the requirements of 210.52(G).

Note

Branch circuits rated 10 amperes are permitted to supply (1) lighting outlets, (2) exhaust fans on bathroom or laundry room lighting circuits, and (3) a gas fireplace unit supplied by an individual branch circuit.

Branch circuits rated 10 amperes are not allowed to supply (1) receptacle outlets; (2) fixed appliances, except as permitted for individual branch circuits; (3) garage door openers; and (4) laundry equipment ***»210.23(A)(1) and (A)(2)«***.





Note

Each outlet for the purpose of supplying electric vehicle supply equipment greater than 16 amps or 120 volts shall be supplied by an individual branch circuit unless the exception can be applied ***»625.40«***.

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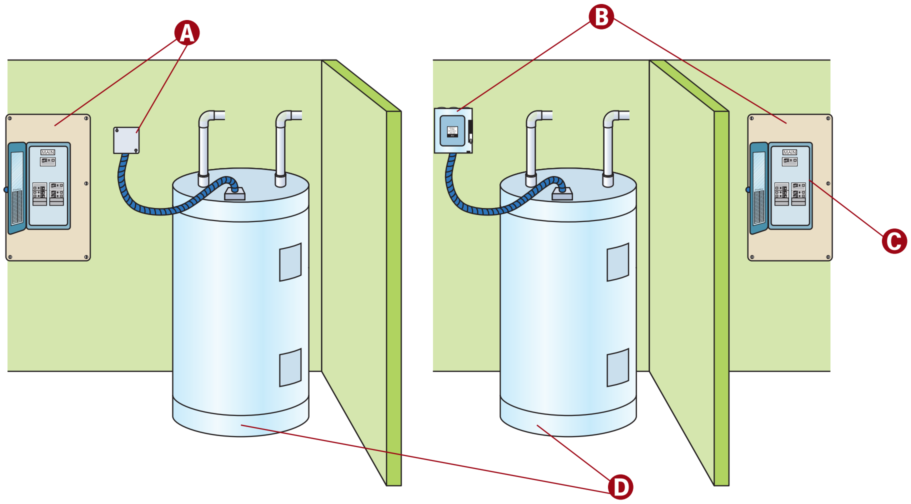
Disconnecting Means for Permanently Connected Appliances

A A disconnecting means is not required if the branch-circuit switch or circuit breaker is within 50 ft (15 m) and can be seen while working on the appliance »*422.31(B)*«.

B A disconnecting means is required unless the branch-circuit switch or circuit breaker can be locked in the open (off) position. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and must remain in place whether the lock is installed or not »*422.31(B)* and *110.25*«.

C In this illustration, the branch-circuit switch or circuit breaker cannot be seen while working on the appliance.

D A permanently connected appliance requires a means to simultaneously disconnect all ungrounded (hot) conductors from the appliance »*422.30*«.



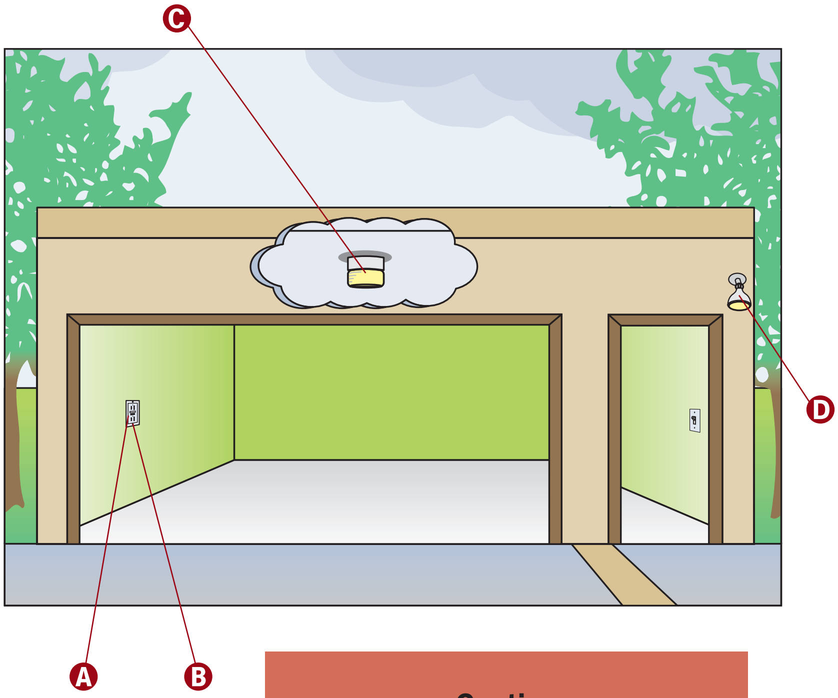
Detached Garages

A At least one receptacle is required in each detached garage with electric power »*210.52(G)(1)*«.

B All receptacles installed in detached garages must have GFCI protection »*210.8(A)(2)*«.

C At least one wall switch–controlled lighting outlet is required for detached garages with electric power »*210.70(A)(2)(1)*«.

D A detached garage with electric power requires at least one wall switch–controlled lighting outlet to provide illumination on the exterior side of an outside entrance or exit with grade-level access »*210.70(A)(2)(2)*«.



Note

Lighting and receptacles are not required in detached garages. There are no provisions to provide electric power to detached garages. However, when electric power is provided, the provisions for attached garages must be met »***210.52(G)(1)***«.

Caution

In dwelling units, all 125-volt and 250-volt, 15- and 20-ampere nonlocking-type receptacles shall be listed tamper-resistant receptacles »*406.12(1)*«.

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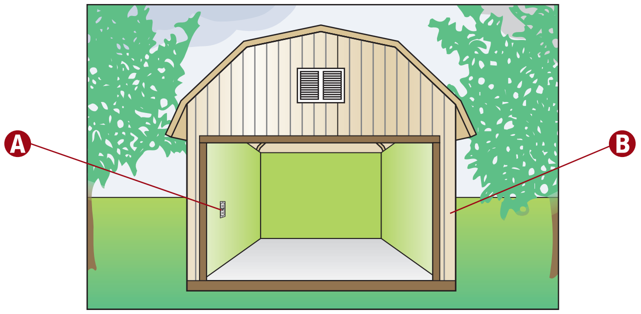
Accessory Buildings

A All receptacles installed in accessory buildings having a floor located at or below grade level not intended as habitable rooms and limited to storage areas, work areas, and areas of similar use must have GFCI protection »*210.8(A)(2)*«.

B Lighting and receptacles are not required in accessory buildings. There are no requirements to provide electric power to detached garages or accessory buildings.



Laundry Areas

Laundry Receptacles and Lighting

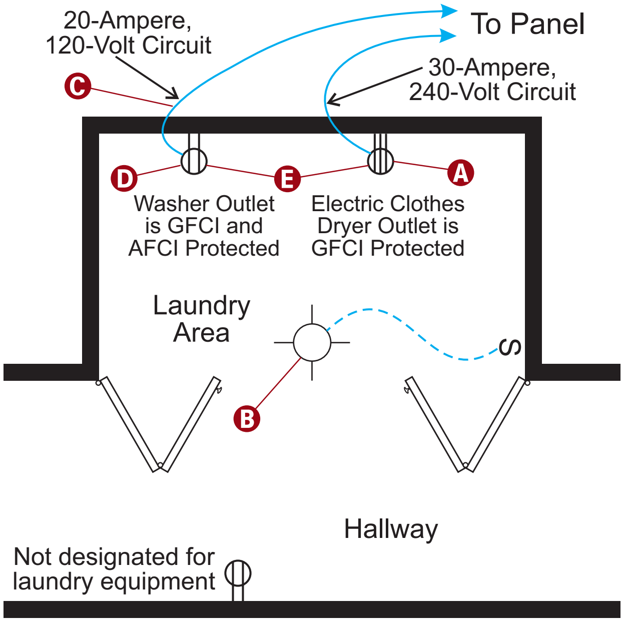
A The clothes dryer outlet must have an insulated grounded (neutral) conductor and an equipment grounding conductor »*250.138*«.

B A lighting outlet is required for spaces containing equipment that requires servicing »*210.70(C)*«.

C Laundry receptacle outlet(s) must be fed from a 20-ampere branch circuit »*210.11(C)(2)*«.

D At least one receptacle outlet shall be installed in areas designated for the installation of laundry equipment »*210.52(F)*«. 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets or devices in laundry areas must be AFCI protected »*210.12(B)(13)*«.

E All 125-volt through 250-volt receptacles installed in the locations specified in 210.8(A)(1) through (A)(12) and supplied by single-phase branch circuits rated 150 volts or less to ground or less shall have ground-fault circuit-interrupter protection for personnel »*210.8(A)*«. Laundry areas are listed in 210.8(A)(11). GFCI protection is required for clothes dryers »*210.8(D)(11)*«.


20-Ampere, 120-Volt Circuit
To Panel
30-Ampere, 240-Volt Circuit
C
D
E
A
Washer Outlet is GFCI and AFCI Protected
Electric Clothes Dryer Outlet is GFCI Protected
Laundry Area
S
B
Hallway
Not designated for laundry equipment

Note

Electric clothes dryers connected to existing branch circuits are permitted to follow ***»250.140(B) and 250.142(B) Exception No. 1«***.

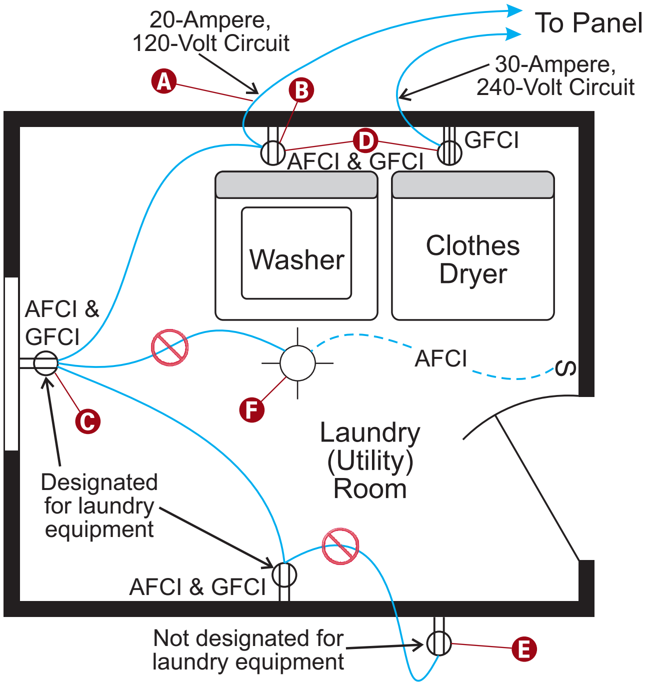
Laundry (Utility) Room

A Laundry receptacle outlet(s) must be fed from a 20-ampere branch circuit »*210.11(C)(2)*«.

B In dwelling units, at least one receptacle outlet shall be installed in areas designated for the installation of laundry equipment »*210.52(F)*«.

C Multiple receptacles are permitted on the laundry circuit as long as all of the outlet(s) are designated for laundry equipment »*210.11(C)(2)*«.

D All 125-volt through 250-volt receptacles installed in the locations specified in 210.8(A)(1) through (A)(12) and supplied by single-phase branch circuits rated 150 volts or less to ground shall have ground-fault circuit-interrupter protection for personnel »*210.8(A)*«. Laundry areas are listed in 210.8(A)(10). GFCI protection is required for clothes dryers »*210.8(D)(11)*«.


20-Ampere, 120-Volt Circuit
To Panel
30-Ampere, 240-Volt Circuit
A
B
D
GFCI
AFCI & GFCI
Washer
Clothes Dryer
AFCI & GFCI
AFCI
S
C
F
Laundry (Utility) Room
Designated for laundry equipment
AFCI & GFCI
Not designated for laundry equipment
E

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E Outlet(s) not designated for laundry equipment are not permitted on a laundry branch circuit »*210.11(C)(2)*«.

F For attics and underfloor spaces, utility rooms, and basements, at least one lighting outlet containing a switch or controlled by a wall switch or listed wall-mounted control device shall be installed where these spaces are used for storage or contain equipment requiring servicing. A point of control shall be at each entry that permits access to the attic and underfloor space, utility room, or basement. Where a lighting outlet is installed for equipment requiring service, the lighting outlet shall be installed at or near the equipment »*210.70(C)*«.

Note

A laundry room/area is not subject to the general provisions for receptacle placement found under 210.52(A). Although additional laundry area receptacles are permitted, only one receptacle outlet is required for the installation of laundry equipment »*210.52(F)*«.

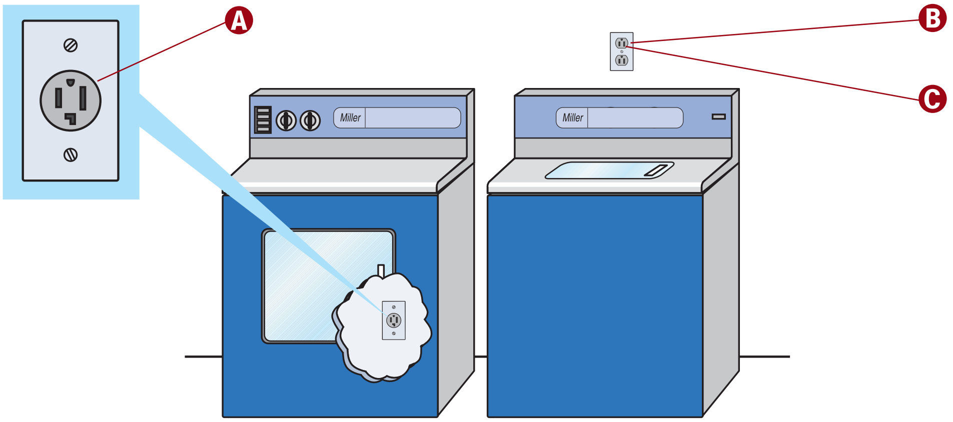
Laundry Receptacle Outlets

A receptacle outlet installed for a specific appliance, such as laundry equipment, shall be installed within 6 ft (1.8 m) of the intended location of the appliance »*210.50(C)*«.

A The clothes dryer outlet must have an insulated grounded (neutral) conductor *and* an equipment grounding conductor »*250.138*«. Because this 240-volt receptacle is located in a laundry area and is installed to supply a clothes dryer, it shall have ground-fault circuit-interrupter protection for personnel »*210.8(A)(11)* and *210.8(D)(11)*«.

B Laundry receptacle outlet(s) must be fed from a 20-ampere branch circuit »*210.11(C)(2)*«. A duplex receptacle installed on an individual 20-ampere branch circuit may have either a 15- or 20-ampere rating »*210.21(B)(3)* and *Table 210.21(B)(3)*«.

C Height requirements for laundry receptacle outlet(s) are not specified, except that they shall not be located more than 5½ ft (1.7 m) above the floor »*210.52*«.



Attic and Crawl Spaces

Attic Spaces

A receptacle is not required for attic spaces that do not contain equipment that may require servicing.

Attic spaces not used for storage or attics that do not contain equipment that may require servicing do not require lighting outlets.

A Attic spaces used for storage or containing equipment requiring servicing shall have at least one lighting outlet. Where a lighting outlet is installed for equipment requiring service, the lighting outlet shall be installed at or near the equipment »*210.70(C)*«.

B At least one switch shall be located at the usual entry and exit to the attic space »*210.70(C)*«. If the lighting outlet contains a switch and is located at the usual point of entry, a separate switch may not be required.

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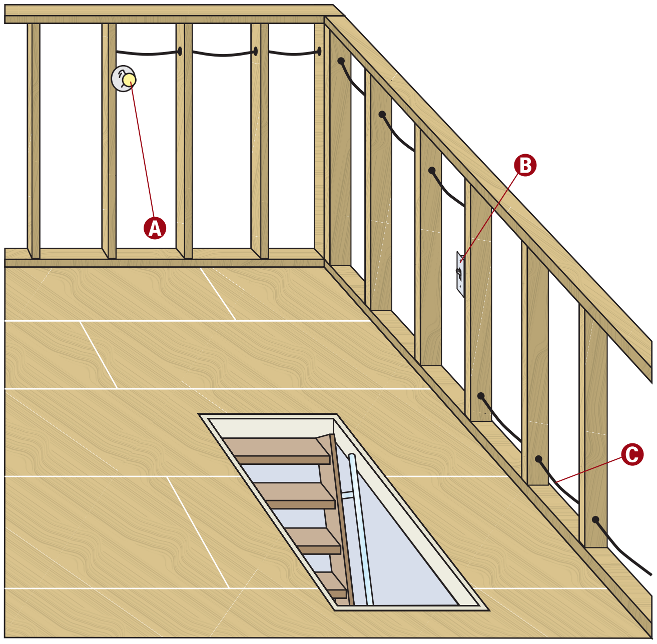


Ⓒ Cables not installed within framing members may need protection up to a height of at least 7 ft (2.1 m) »*320.23(A), 330.23,* and *334.23*«.

Crawl and Underfloor Spaces

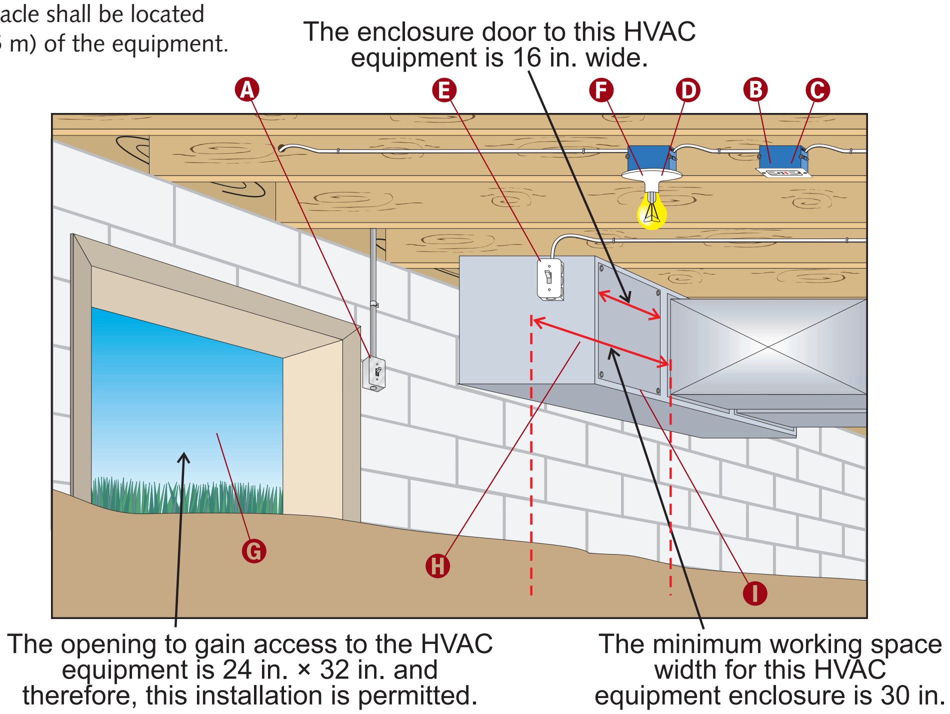
Ⓐ Crawl spaces with lighting outlet(s) require at least one switch located at the usual entry and exit to the crawl space »*210.70(C)*«. If the luminaire contains a switch and is located at the usual point of entry, a separate switch may not be required.

Ⓑ A 125-volt, single-phase, 15- or 20-ampere rated receptacle outlet shall be installed at an accessible location for the servicing of equipment. The receptacle shall be located on the same level and within 25 ft (7.5 m) of the equipment. The receptacle shall not be connected to the load side of the equipment's branch-circuit disconnecting means »*210.63*«.

Ⓒ Receptacle outlet(s) require GFCI protection where installed in a crawl space that is at or below grade level »*210.8(A)(4)*«.

Caution

Where cable is run at angles with joists in crawl spaces, it shall be permissible to secure cables not smaller than two 6 AWG or three 8 AWG conductors directly to the lower edges of the joists. Smaller cables must be run either through bored holes in joists or on running boards »*334.15(C)*«.


The enclosure door to this HVAC equipment is 16 in. wide.
A
E
F
D
B
C
G
H
I
The opening to gain access to the HVAC equipment is 24 in. × 32 in. and therefore, this installation is permitted.
The minimum working space width for this HVAC equipment enclosure is 30 in.

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Ⓓ Underfloor spaces used for storage containing equipment requiring servicing shall have at least one lighting outlet. Where a lighting outlet is installed for equipment requiring service, the lighting outlet shall be installed at or near the equipment »*210.70(C)*«.

Ⓔ A disconnecting means must be provided for HVAC equipment »*440.12*, *422.30*, and *424.19*«.

Ⓕ GFCI protection shall be provided for lighting outlets not exceeding 120 volts installed in crawl spaces »*210.8(C)*«.

Ⓖ Where equipment operating at 1000 volts, nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized is required by installation instructions or function to be located in a space with limited access (such as a crawl space), there shall be an accessible opening not smaller than 22 in. × 30 in. (559 mm × 762 mm) »*110.26(A)(4)*«.

Ⓗ The width of the working space shall be the width of the equipment enclosure or a minimum of 30 in. (762 mm), whichever is greater »*110.26(A)(4)(b)*«.

Ⓘ The space in front of the enclosure shall comply with the depth requirements of Table 110.26(A)(1). The maximum height of the working space shall be the height necessary to install the equipment in the limited space »*110.26(A)(4)(4)*«.

No lighting outlets are required for underfloor spaces that are not used for storage or contain no equipment that may require servicing.

Summary

- Receptacle branch circuits rated 20 amperes are required for small-appliance branch circuits in kitchens, pantries, dining rooms, breakfast rooms, and similar areas.
- The maximum distance to any countertop receptacle, along the wall line measured horizontally, is 24 in. (600 mm).
- General provisions for countertop receptacle placement do not apply to islands and peninsulars.
- A minimum of two circuits is required for receptacles serving kitchen countertops.
- Receptacles located in kitchens, pantries, dining rooms, breakfast rooms, and similar areas also require a minimum of two circuits.
- All receptacles installed in kitchens shall have GFCI protection.
- A receptacle installed within 6 ft (1.8 m) from the top inside edge of the bowl of the sink shall have GFCI protection.
- Some appliances can be cord and plug connected.
- Permanently connected as well as cord- and plug-connected appliances require a disconnecting means.
- Branch-circuit conductors installed for ranges and clothes dryers must have an insulated grounded (neutral) conductor and a grounding means.
- Hallways measuring 10 ft (3.0 m) or more in length require only one receptacle.
- Clothes closets have dedicated space where luminaires are not permitted.
- Only certain types of luminaires are permitted in the dedicated space within bathrooms.
- Receptacles in bathrooms must be GFCI protected and be supplied by 20-ampere branch circuit(s).
- All garage receptacles require GFCI protection.
- At least one 120-volt, 20-ampere branch circuit shall be installed to supply receptacle outlets in attached garages and in detached garages with electric power.
- Lighting is required at or near equipment that may require servicing.
- All 125-volt through 250-volt receptacles supplied by single-phase branch circuits rated 150 volts or less to ground installed in laundry areas shall have GFCI protection.
- Under certain conditions, attics and crawl spaces may require a lighting outlet and receptacle.
- Lighting outlets not exceeding 120 volts installed in crawl spaces shall be GFCI protected.
- A receptacle is required on the same level and within 25 ft (7.5 m) of HVAC equipment that may require servicing.
- GFCI protection shall be provided for outlets that supply dishwashers installed in dwelling unit locations.

Unit 7 Competency Test

***NEC*® Reference** **Answer**

____________ ____________ 1. The maximum spacing between kitchen countertop receptacles in a dwelling unit is ____________ ft.

____________ ____________ 2. Hanging luminaires located directly above any part of the bathtub shall be installed so that the luminaire is not less than ____________ ft above the top of the bathtub rim.

***NEC*® Reference** **Answer**

___________ ___________ 3. A 15-ampere rated duplex receptacle may be installed on a ___________ branch circuit.

a) 15-ampere b) 20-ampere

c) 15- or 20-ampere d) 15-, 20-, or 25-ampere

___________ ___________ 4. The minimum size THHN copper neutral conductor permitted for an 8¾ kW, 240-volt, 3-wire household electric range is ___________.

a) 12 AWG b) 10 AWG c) 8 AWG d) 6 AWG

___________ ___________ 5. Luminaires shall be constructed or installed so that adjacent combustible material will not be subjected to temperatures in excess of ___________ °Fahrenheit.

___________ ___________ 6. A one-family dwelling has a front entrance on the east side of the house, an attached garage with two 10-ft wide doors on the south side, and a back entrance door on the west side of the house. This one-family dwelling requires ___________ lighting outlet(s) for these outdoor entrances.

___________ ___________ 7. Overcurrent protective devices shall not be located in the vicinity of easily ignitible material such as in ___________.

___________ ___________ 8. A single receptacle installed on an individual branch circuit shall have an ampere rating not less than ___________% of the rating of the branch circuit.

a) 125 b) 100 c) 80 d) 50

___________ ___________ 9. Appliance receptacle outlets installed for specific appliances, such as laundry equipment, shall be placed within ___________ ft of the intended location of the appliance.

___________ ___________ 10. Tap conductors for household cooking equipment supplied from a 50-ampere branch circuit shall have an ampacity of not less than ___________ amperes.

___________ ___________ 11. One cooktop and two ovens are connected to one branch circuit in a kitchen of a one-family dwelling. The cooktop has a nameplate rating of 4 kW at 240 volts, while each oven has a nameplate rating of 5.5 kW at 240 volts. The minimum load calculation for this branch circuit is ___________ watts.

___________ ___________ 12. The rating of a single cord- and plug-connected utilization equipment shall not exceed ___________% of the branch-circuit ampere rating.

___________ ___________ 13. A recessed incandescent luminaire with a completely enclosed light source installed in the ceiling of a clothes closet must have a minimum clearance of ___________ in. between the luminaire and the nearest point of the closet storage space.

___________ ___________ 14. Where the *NEC* specifies that one equipment shall be "in sight of" another equipment, the specified equipment shall be visible and not more than ___________ ft distant from the other.

___________ ___________ 15. In a dwelling unit, a hallway measuring 21½ ft in length requires a minimum of ___________ receptacle outlet(s).

___________ ___________ 16. A permanently connected dishwasher has a nameplate rating of 780 volt-amperes. The circuit breaker is permitted to serve as the disconnecting means where it is:

I. within sight from the dishwasher.

II. lockable in accordance with 110.25.

III. capable of being locked in the closed position.

a) I only b) I or III only c) I or II only d) I, II, or III

___________ ___________ 17. Interior stairway lighting outlets shall be controlled by a wall switch at each floor level, where the difference between levels is ___________ steps or more.

NEC® Reference **Answer**

____________ ____________ 18. Supplementary overcurrent devices shall not be required to be ____________.

____________ ____________ 19. The maximum length cord permitted on a built-in dishwasher is ____________ ft.

____________ ____________ 20. For a one-family dwelling, at least one receptacle outlet shall be installed in each:

I. basement.
II. attached garage.
III. detached garage.
a) I only b) I and II only c) II and III only d) I, II, and III

____________ ____________ 21. A refrigerator receptacle can be fed from a:

I. 15-ampere individual branch circuit.
II. 20-ampere individual branch circuit.
III. 20-ampere small appliance branch circuit.
a) II only b) III only c) II or III d) I, II, or III

____________ ____________ 22. A receptacle installed in an area designated for the installation of laundry equipment and where there are no other receptacles can be a:

I. 15-ampere single receptacle.
II. 15-ampere duplex receptacle.
III. 20-ampere duplex receptacle.
a) III only b) I or III c) II or III d) I, II, or III

____________ ____________ 23. At least one GFCI-protected receptacle shall be located within ____________ ft from the outside edge of each bathroom sink.

____________ ____________ 24. If a receptacle outlet is not installed to serve an island or peninsular countertop in a dwelling unit, ____________.

____________ ____________ 25. A branch circuit providing power to a bathroom receptacle may also provide power to:

I. two other receptacles, two luminaires, and an exhaust fan in the same bathroom.
II. two other receptacles in the same bathroom and receptacles in two additional bathrooms.
III. one luminaire in the same bathroom and one luminaire in another bathroom.
a) I only b) I or II only c) II or III only d) I, II, or III

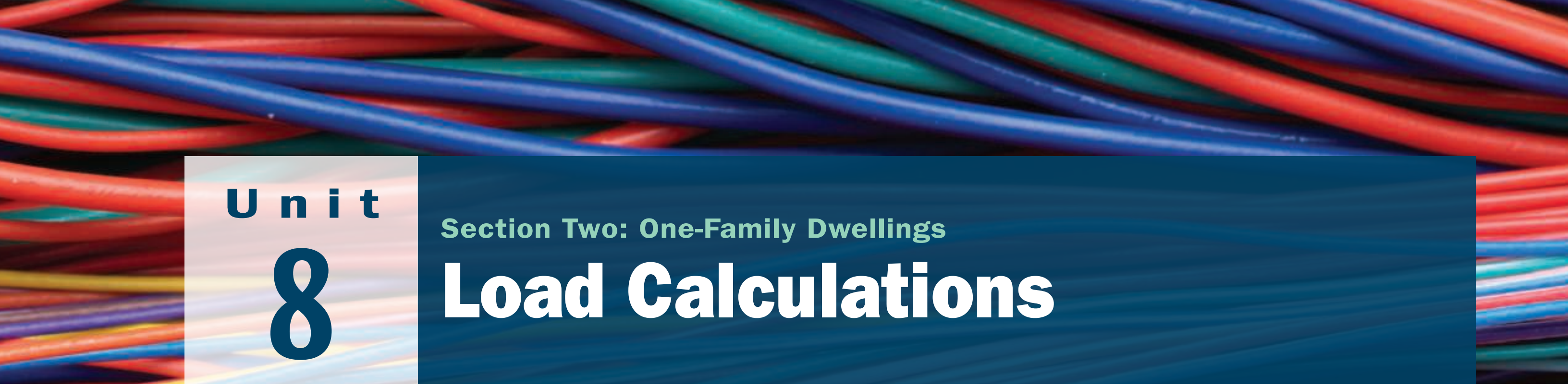
____________ ____________ 26. In addition to the number of branch circuits required by other parts of Article 210, at least one 120-volt, ____________ ampere branch circuit shall be installed to supply receptacle outlets in attached garages and in detached garages with electric power.

____________ ____________ 27. Where equipment operating at 1000 volts, nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized is required by installation instructions or function is located in a crawl space limited access, there shall be an accessible opening not smaller than ____________ in. × ____________ in.

____________ ____________ 28. What is the minimum number of 20-ampere small-appliance branch circuits required for a kitchen with 27 linear feet of countertop and an island that measures 2 ft by 6 ft?

____________ ____________ 29. The ground-fault circuit interrupter shall be installed in a ____________ location.

____________ ____________ 30. A 125-volt, single-phase, 15- or 20-ampere rated receptacle outlet shall be installed at an accessible location within ____________ ft of heating, air-conditioning, and refrigeration equipment.



Unit 8

Section Two: One-Family Dwellings

Load Calculations

Objectives

After studying this unit, the student should be able to:

- calculate the general lighting load in a one-family dwelling.
- recall the minimum volt-ampere (VA) requirements for small-appliance and laundry branch circuits.
- explain how to apply demand factors to the general lighting load.
- clarify demand factors to fastened-in-place appliances.
- calculate feeder-demand loads for household electric clothes dryers.
- calculate feeder-demand loads for household electric cooking appliances.
- calculate heating and air-conditioning feeder-demand loads.
- calculate a one-family dwelling service or feeder using the standard method.
- calculate a one-family dwelling service or feeder using the optional method.
- explain how to size service and feeder conductors.
- calculate and choose the appropriate size neutral conductor.
- recall how the grounding electrode conductor is selected.

Introduction

Load calculations must be performed in order to determine the size of services and feeders. Service conductors are the conductors between the power provider and the disconnecting means, whether a main breaker or main lug panel. A feeder is defined as all circuit conductors between the service disconnecting means and the panelboard containing fuses or breakers that feed branch circuits. Additional load calculations are needed for dwellings with panelboards that are not part of the service. For example, a separate panelboard might be installed near the middle of the house to help eliminate voltage drop in branch-circuit conductors. Since the remote panelboard (subpanel) does not carry the total load, an additional calculation is needed to size the feeder and panelboard.

This unit simplifies the standard and optional load calculation methods for one-family dwellings. A blank form is provided at the beginning of each method. The floor plan of the one-family dwelling being calculated is found on page 114 while the specifications are on page 168. Both calculation methods use the same specifications. Each line on each form is explained in detail using that information. The completed form follows the explanations.

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Compiling Information Essential to Load Calculations

Total Floor Area Square Footage

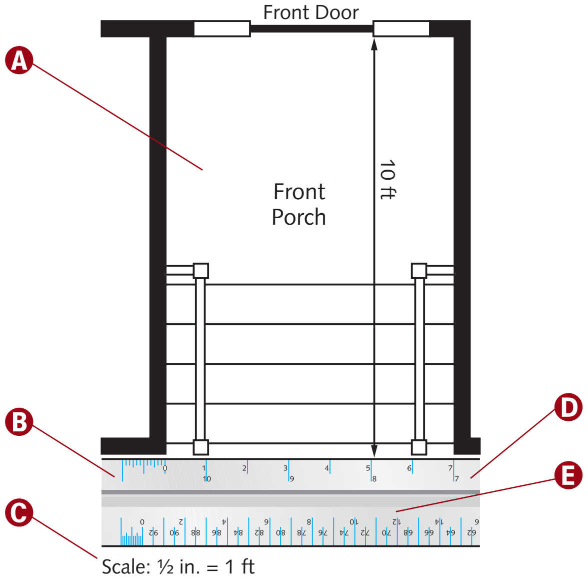
A Open porches are not included in the calculated floor area of dwelling units »*220.5(C)*«. Although this porch has a roof, it is considered open and, therefore, is not included in the calculation.

B Scale rulers are also useful in determining the location of outlets (receptacles, lights, switches, etc.).

C Before a scale ruler can be used to determine dimensions, the scale used to produce the blueprint (floor plan) must be known. (Then the area of an exterior porch, for example, is simple to calculate.)

D Scale rulers are useful in determining the total square footage of a structure (house, building, etc.) that has been drawn on a set of blueprints (floor plans).

E A regular tape measure (ruler, yard stick, etc.) can be used, but the use of a scale ruler makes the job much easier.



Gathering Information

Gathering certain information is necessary to accurately perform load calculations. All the essential data can be identified by simply answering the questions found on the load calculation form, either standard or optional. Enter the information on the appropriate line of the load calculation forms provided with this textbook.

A What is the dwelling's total square-foot (ft²) area, using the outside dimensions?

B What fastened-in-place appliances will be installed and what is the volt-ampere load of each?

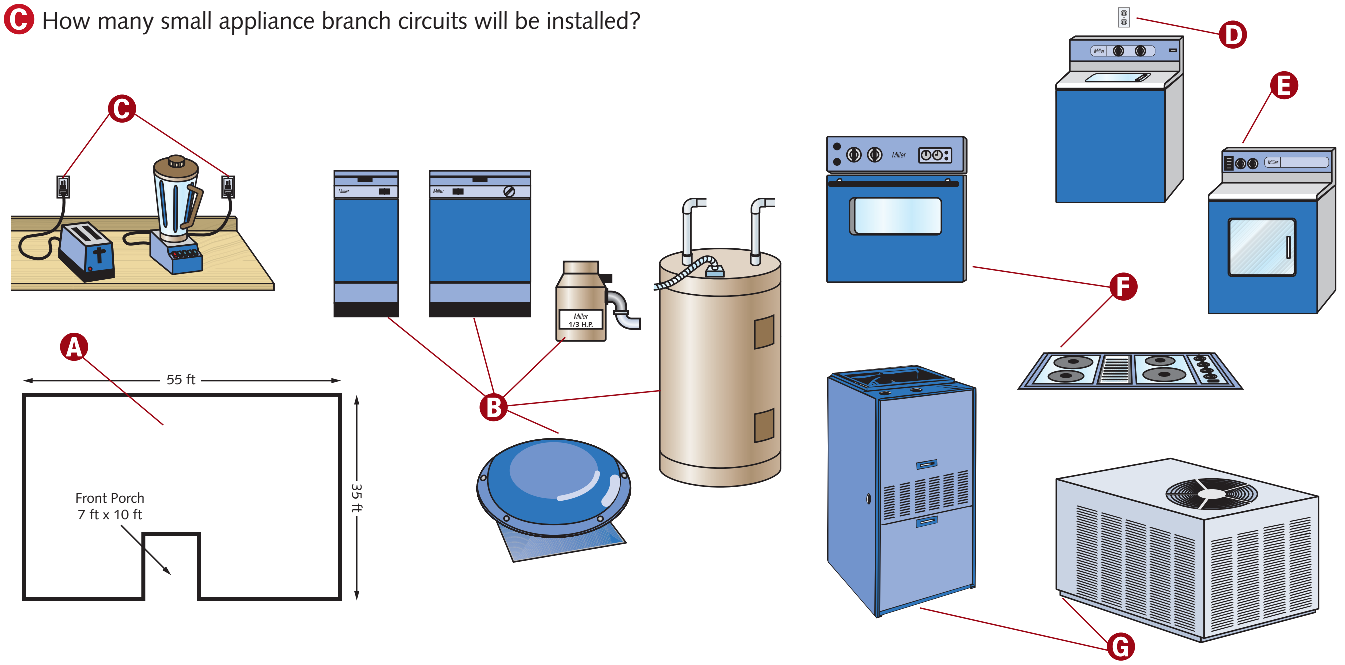
C How many small appliance branch circuits will be installed?

D How many laundry circuits will be installed?

E If an electric clothes dryer will be installed, what is the volt-ampere load?

F What household electric cooking equipment will be installed and what is the volt-ampere load of each?

G Will there be an air-conditioning system? If so, what is the total volt-ampere load, including the compressor and fan motors? If an electric heating system will be installed, what is the total volt-ampere load, including the strip heat and blower motor?



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Standard Method: One-Family Dwellings

Standard Method Load Calculation for One-Family Dwellings

1 General Lighting and Receptacle Loads *220.41* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*	3 × ______________ = (sq ft using outside dimensions)	1	
2 Small-Appliance Branch Circuits *220.52(A)* *At least* ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*	1500 × ______________ = (minimum of two)	2	
3 Laundry Branch Circuit(s) *220.52(B)* *At least* ***one*** *laundry branch circuit must be included. 210.11(C)(2)*	1500 × ______________ = (minimum of one)	3	
4 Add lines 1, 2, and 3		4	
Lines 5 through 8 utilize the demand factors found in *Table 220.45.*			
5 ______________ – 3000 = (line 4)	(if 117,000 or less, skip to line 8)	5	
6 ______________ – 117,000 = (line 5, if more than 117,000)		6	
7 ______________ × 25% = (line 6)		7	
8 ______________ × 35% = (smaller of line 5 or 117,000)		8	
9 Total General Lighting and Receptacle Load	3000 + ______________ + ______________ = (line 7) (line 8)	9	
10 Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or greater *220.53* *Use the nameplate rating.* *Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.*	water heater / ______ dishwasher / ______ disposer / ______ compactor / ______ ______ / ______ ______ / ______ ______ / ______ ______ / ______ ______ / ______		
If fewer than four units, put total volt-amperes on line 10. If four or more units, multiply total volt-amperes by 75%.	______________ × 75% = (volt-amps of four or more)	10	
11 Electric Clothes Dryers *220.54* *(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.* The neutral demand load is 70% for services and feeders. *220.61(B)*		11	
12 Household Electric Cooking Appliances over 1750 Watts *220.55* *(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.* The neutral demand load is 70% for services and feeders. *220.61(B)*		12	
13 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60* *Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*		13	
14 Largest Motor (one motor only) *220.50*, *440.32* through *.35*, and *430.24* through *.26* *Multiply the volt-amperes of the largest motor by 25%.* *If 25% of the largest motor is in Line 13, leave Line 14 blank.*	______________ × 25% = (volt-amps of largest motor)	14	
15 Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.*		15	
16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	______________ ÷ ______________ = (line 15) (voltage)	16	(minimum amperes)
17 **Minimum Size Service or Feeder** ***240.6(A)***		17	
18 Size the Service or Feeder Conductors. *Use Table 310.12(A) to find the service conductors up to 400 amperes.* *Ratings in excess of 400 amperes shall comply with Table 310.16.* *Table 310.12(A) also applies to feeder conductors supplying the entire load.*	**Minimum Size Conductors**	18	
19 Size the Neutral Conductor. *220.61* *310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded ("hot") conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	19	
20 Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor**	20	

Sample One-Family Dwelling Load Calculation

Assume water heater, clothes dryer, counter-mounted cooking unit, wall-mounted oven, and electric heat kilowatt (kW) ratings equivalent to kilovolt-ampere (kVA).

Note

The information to the right will be used throughout the remainder of this unit to demonstrate the use of the load calculation forms, both standard and optional.

Dwelling outside dimension	35 ft × 55 ft
Front porch (included within outside dimensions)	7 ft × 10 ft
Small-appliance branch circuits	four
Laundry branch circuits	two
Water heater	4.5 kW, 240 volt
Dishwasher	10 amperes, 120 volt
In-sink waste disposer	½ hp, 115 volt
Trash compactor	7.5 amperes, 120 volt
Three attic fans (4.2 amperes each)	12.6 amperes, 120 volt
Electric clothes dryer	5.5 kW, 240 volt
Counter-mounted cooking unit (cooktop)	7 kW, 240 volt
Wall-mounted oven	6 kW, 240 volt
Electric heat (three banks at 5 kW each)	15 kW, 240 volt
Air handler (blower motor)	3.2 amperes, 115 volt
Air-conditioner compressor motor	16.6 amperes, 230 volt
Condenser fan motor	2 amperes, 115 volt

Line 1—General Lighting and Receptacle Loads

A Section 220.41 requires a minimum load of 3 volt-amperes/ft^2 (33 volt-amperes/m^2) for the lighting and general use receptacle outlets in a dwelling unit.

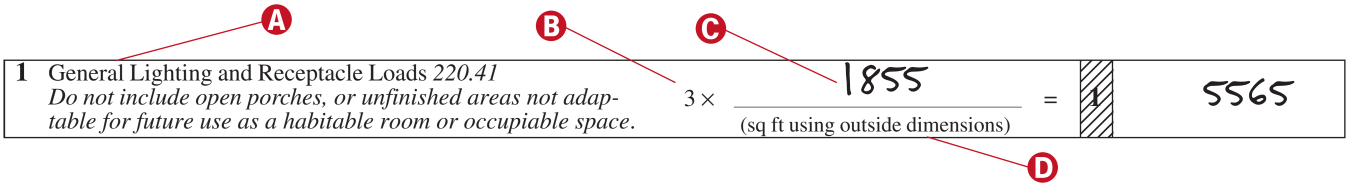
B The lighting load for residential dwelling units is 3 volt-amperes (VA) per square foot.

C The dwelling floor plan on page 114 has an outside dimension of 35 ft × 55 ft (1925 ft^2), but there is an open porch with a dimension of 7 ft × 10 ft (70 ft^2). Since open porches are not included in the total area, 70 is deducted from 1925, leaving 1855 ft^2.

D The floor area for each floor shall be computed using the outside dimensions. The total floor area does not include open porches or unfinished areas not adaptable for future use as a habitable room or occupiable space »*220.5(C)*«.

Note

All 15- or 20-ampere general-use receptacle outlets (except for small-appliance and laundry outlets) are considered part of the general lighting load. No additional load calculations are required for these outlets »***220.41***«.



1 General Lighting and Receptacle Loads *220.41*
Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.
3 × 1855 = 1 5565
(sq ft using outside dimensions)

Line 2—Small-Appliance Branch Circuits

A Small-appliance branch circuits must be included when calculating a dwelling unit service »*220.52(A)*«.

B Each small-appliance branch circuit is calculated at no less than 1500 volt-amperes »*220.52(A)*«.

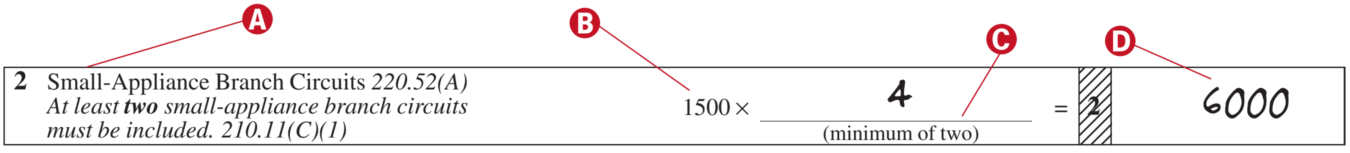
C A dwelling unit must have at least two small-appliance branch circuits »*210.11(C)(1)*«.

D These loads can be included with the general lighting load and subjected to the demand factors provided in Table 220.45 »*220.52(A)*«.

Note

An individual branch circuit for refrigeration equipment (permitted by 210.52(B)(1) Exception No. 2) can be excluded from this calculation »***220.52(A) Exception***«.

If a dwelling has more than one feeder, a separate load calculation is needed for each. It is not necessary to include this step if a feeder does not supply small-appliance branch circuits. A load calculation for a feeder supplying small-appliance branch circuits must include at least 1500 volt-amperes for each 2-wire circuit »***220.52(A)***«.



2 Small-Appliance Branch Circuits *220.52(A)*
*At least **two** small-appliance branch circuits must be included. 210.11(C)(1)*
1500 × 4 = 2 6000
(minimum of two)

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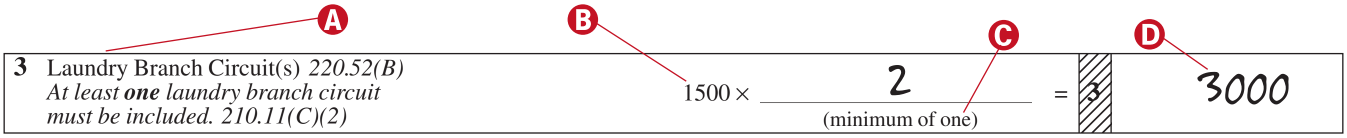
Line 3—Laundry Branch Circuits

A Laundry branch circuits must be included when calculating a dwelling unit service »*220.52(B)*«.

B Each laundry branch circuit is calculated at no less than 1500 volt-amperes »*220.52(B)*«.

C At least one laundry branch circuit is required per dwelling unit »*210.11(C)(2)*«.

D These loads can be included with the general lighting load and subjected to the demand factors provided in Table 220.42 »*220.52(B)*«.



3	Laundry Branch Circuit(s) *220.52(B)* *At least **one** laundry branch circuit must be included. 210.11(C)(2)*	1500 × 2 (minimum of one)	=	3	3000

Lines 4 through 8—Applying Demand Factors Found in Table 220.42

A Line 4 is simply the total of lines 1 through 3.

B Lines 5 through 8 outline the procedure that derates by using demand factors provided in Table 220.45.

C Line 5 is the result of subtracting 3000 from the number in line 4.

D The first 3000 (or less) volt-amperes must remain at 100% »*Table 220.45*«.

E If line 5 is 117,000 or less, then lines 6 and 7 can be skipped.

F If Line 4 is 120,000 or less, then lines 6 and 7 will remain empty.

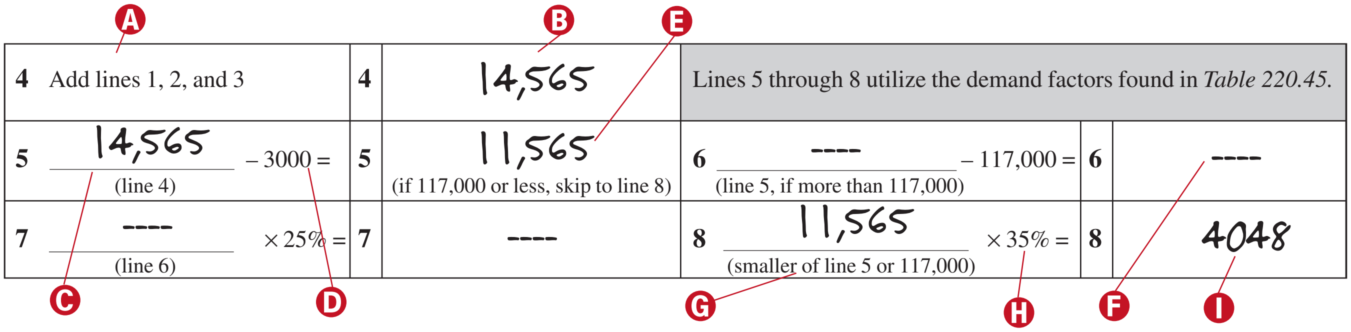
G Insert the smaller of line 5 or 117,000.

H The next 117,000 (from 3001 to 120,000) is multiplied by 35% »*Table 220.45*«.

I The result found on line 8 has been rounded up from 4047.75 to the next whole number, thus eliminating the decimal.

Note

Generally, one-family dwelling load calculations will not use lines 6 and 7. (For example, a one-family dwelling with a total floor area of 25,000 ft^2, twenty small-appliance circuits and ten laundry branch circuits will not need lines 6 and 7.)



4	Add lines 1, 2, and 3	**4**	14,565	Lines 5 through 8 utilize the demand factors found in *Table 220.45.*			
5	14,565 (line 4) – 3000 =	**5**	11,565 (if 117,000 or less, skip to line 8)	**6**	---- (line 5, if more than 117,000) – 117,000 =	**6**	----
7	---- (line 6) × 25% =	**7**	----	**8**	11,565 (smaller of line 5 or 117,000) × 35% =	**8**	4048

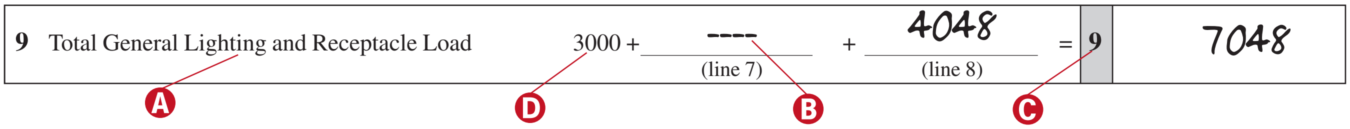
Line 9—Total General Lighting (and Receptacle) Load

A Line 9 is the total of general lighting and general-use receptacles, small-appliance branch circuits, and laundry branch circuits after derating.

B If line 7 was skipped (left blank), leave this space blank also.

C This shaded block draws attention to the first of six lines (boxes) that will be added together to give the total volt-ampere demand load for the one-family dwelling.

D If performing a load calculation for a feeder (and panel) that supplies less than 1000 ft^2 of floor area and does not supply small-appliance or laundry branch circuits, the result could be less than 3000. For example, if a feeder is installed to supply only 800 ft^2 of floor area and will not supply any small appliance or laundry branch circuits, then line 9 will be 2400 (3 VA per ft^2 × 800 ft^2 = 2400).



9	Total General Lighting and Receptacle Load	3000 + ---- (line 7) + 4048 (line 8)	=	9	7048

Line 10—Fastened-In-Place Appliances

A The term **appliance** designates utilization equipment commonly built in standardized types and sizes, and installed as a unit to perform specific function(s) »*Article 100*«.

B For the purpose of this load calculation, a kW rating will be the same as a kVA rating.

C Multiplying voltage by amperage produces volt-amperes (VA).

D Horsepower ratings must be converted to volt-amperes (VA) before they can be added to this form. The full load current ratings for single-phase motors are found in Table 430.248. Multiply the amperes (9.8) by the rated voltage (115) to find the volt-amperes (1127).

E No derating is allowed when there are only one, two, or three fastened-in-place appliances.

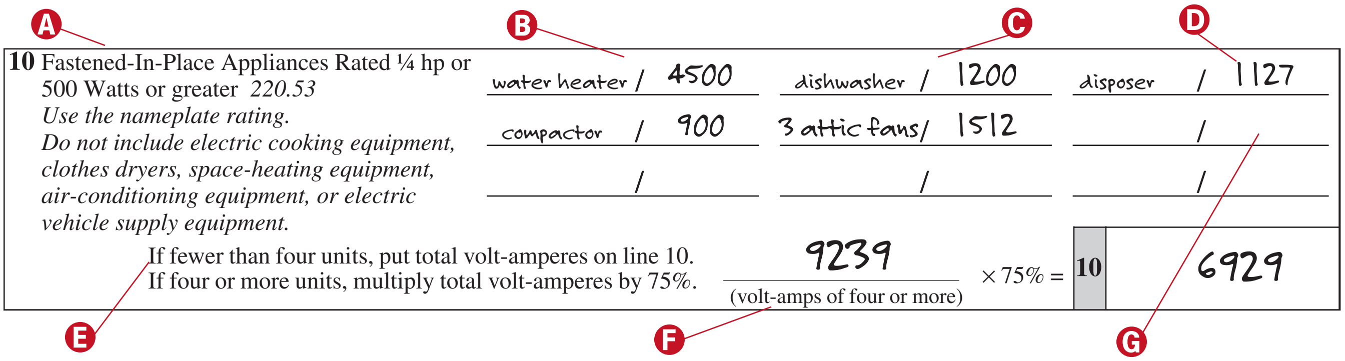
F If the service or feeder being calculated contains at least four fastened-in-place appliances, the combined volt-ampere rating of those appliances is multiplied by 75% and placed on line 10 »*220.53*«.

G Space is provided for additional fastened-in-place appliances.

Note

Household electric cooking equipment that is fastened in place, dryers, space-heating equipment, air-conditioning equipment, and electric vehicle supply equipment are not included as fastened-in-place appliances »***220.53***«.

Household cooking appliances individually rated in excess of 1750 watts are derated under 220.55 provisions; see Line 12.



10 Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or greater *220.53*
Use the nameplate rating.
Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.

water heater / 4500	dishwasher / 1200	disposer / 1127
compactor / 900	3 attic fans / 1512	/
/	/	/

If fewer than four units, put total volt-amperes on line 10.
If four or more units, multiply total volt-amperes by 75%. 9239 (volt-amps of four or more) × 75% = **10** 6929

Line 11—Electric Clothes Dryers

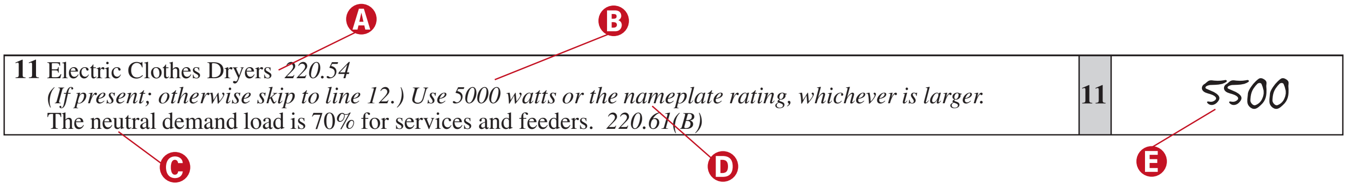
A A clothes dryer is not a requirement for a load calculation. Skip this line if there is no clothes dryer.

B If one of the circuits on the feeder being calculated is a clothes dryer, the rating for the dryer must be at least 5000 watts (volt-amperes) »*220.54*«.

C An electric clothes dryer neutral load on a service or feeder can be calculated at 70% »*220.61(B)*«.

D If the nameplate rating is more than 5000 watts (volt-amperes), the larger number is used »*220.54*«.

E 5.5 kW is equal to 5500 watts (volt-amperes).



11 Electric Clothes Dryers *220.54*
(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.
The neutral demand load is 70% for services and feeders. *220.61(B)* **11** 5500

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Line 12—Household Electric Cooking Appliances

A Household electric cooking appliances (ranges, wall-mounted ovens, counter-mounted cooking units, etc.) are not required in a load calculation. Skip this line if there are no cooking appliances rated over 1¾ kW.

B Individual household cooking appliances rated more than 1750 watts (volt-amperes) can be derated by using Table 220.55 demand factors (and all of the applicable notes).

C The neutral load on a service or feeder can be calculated at 70% for household electric ranges, wall-mounted ovens, and counter-mounted cooking units »*220.61(B)*«.

D A 7-kW counter-mounted cooking unit (cooktop) and a 6-kW wall-mounted oven are included in this calculation. Both units fall within the parameters of Column B. The demand factor percentage found in that column for 2 units is 65%. Multiply the total kW (13) by the demand factor percentage (65%) to find the derated load (8.45 kW); 8.45 kW is equal to 8450 watts (volt-amperes).

A B D

12 Household Electric Cooking Appliances over 1750 Watts *220.55* *(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.* The neutral demand load is 70% for services and feeders. *220.61(B)*	**12**	8450

C

Line 13—Heating or Air-Conditioning System

A The smaller of two (or more) **noncoincident loads** can be omitted, as long as they are never energized simultaneously »*220.60*«. By definition, noncoincident means not occurring at the same time. A dwelling's electric heating system and air-conditioning system may be noncoincident loads.

B The air handler (blower motor) has a rating of 368 volt-amperes (3.2 × 115 = 368). Since both loads are energized simultaneously, add the air handler to the 15 kW of electric heat.

C Fixed electric space heating loads are calculated at 100% of the total connected load »*220.51*«.

D The air handler (blower) works with either the heating or the air conditioning. Add it to both calculations.

E The air-conditioner compressor (16.6 × 230 × 125% = 4773 VA), condenser fan motor (2 × 115 = 230 VA), and blower motor (3.2 × 115 = 368 VA) have a combined load of 5271 volt-amperes. Because this total is less than the heating load even with the additional 25%, omit the air-conditioner compressor and the condenser fan motor.

Note

A heat pump with supplementary heat is not considered a noncoincident load. Add the compressor full-load current to the maximum amount of heat that can be energized while the compressor is running. Remember to include all associated motors—blower, condenser, etc.

Note

If a motor or air-conditioning load is part of the noncoincident load and is not the largest of the noncoincident loads, 125% of either the motor load or air-conditioning load, whichever is larger, shall be used in the calculation »***220.60***«.

A B C

13 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60* *Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*	**13**	15,368

D E

Line 14—Largest Motor

A Multiply the largest motor in the dwelling calculation by 25% »*220.50*, *440.32* through *.35*, and *430.24* through *.26*«.

B The largest motor is usually the air-conditioner compressor. If the air-conditioner load has been omitted, use the second largest motor. In this case, use the ½-horsepower in-sink waste disposer motor.

C The result of 281.75 has been rounded up, thus eliminating the decimal.

Note

If the largest motor is the air-conditioner compressor motor and it was not omitted, it is already in the calculation at 125%. When 25% of the largest motor is in Line 13, leave Line 14 blank or insert a zero.

A B C

14 Largest Motor (one motor only) *220.50*, *440.32* through *.35*, and *430.24* through *.26* *Multiply the volt-amperes of the largest motor by 25%.* *If 25% of the largest motor is in Line 13, leave Line 14 blank.*	1127 (volt-amps of largest motor)	× 25% =	**14**	282

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Line 15—Total Demand Load

Ⓐ Add lines 9 through 14 to find the service's minimum volt-ampere load.

Ⓐ

15 Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.*	**15**	43,577

Lines 16 and 17—Minimum Service or Feeder

Ⓐ Place the total volt-ampere amount found in line 15 here.

Ⓑ Write down the source voltage that will supply the feeder.

Ⓒ It is permissible to round calculations to the nearest whole ampere. Fractions of an ampere 0.5 and higher are rounded up, while fractions less than 0.5 are dropped »*220.5(B)*«.

Ⓓ The service (or feeder) overcurrent protection must be higher than the number found in line 16. A list of standard ampere ratings for fuses and circuit breakers is provided in 240.6(A) and Table 240.6(A).

Ⓔ Find the amperage by dividing the volt-amperes by the voltage.

Ⓕ This is the minimum amperage rating required for the service or feeder being calculated.

Ⓖ The next standard size fuse or breaker above 182 amperes is 200 »*Table 240.6(A)*«.

Note

For a one-family dwelling, the service disconnecting means shall have a rating of not less than 100 amperes, 3-wire ***»230.79(C)«***.

Ⓐ Ⓑ Ⓒ Ⓓ

16 Minimum Amperes *Divide the total volt-amperes by the voltage*	43,577 (line 15)	÷	240 (voltage)	=	**16**	182 (minimum amperes)	**17** **Minimum Size Service or Feeder *240.6(A)***	**17**	200

Ⓔ Ⓕ Ⓖ

Line 18—Minimum Size Conductors

Ⓐ For a service rated 100 through 400 A, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83% of the service rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied »*310.12(A)* and *Table 310.12(A)*«.

Ⓑ Table 310.12(A) also applies to feeder conductors that supply the entire load associated with a one-family dwelling »*310.12(B)*«.

Ⓒ The maximum service or feeder rating permitted when using Table 310.12(A) is 400 amperes.

Ⓓ In the 75°C (167°F) of Table 310.16, the size copper conductor required for 200 amps is 3/0 AWG. However, since this is a dwelling service, select the conductor from Table 310.12(A). The minimum size copper conductor is 2/0 AWG »*Table 310.12(A)*«.

Ⓔ Table 310.12(A) provides sizes for both copper and aluminum conductors. Copper-clad aluminum conductors are listed in the column with aluminum.

Ⓐ Ⓑ Ⓒ Ⓓ

18 Size the Service or Feeder Conductors. *Use Table 310.12(A) to find the service conductors up to 400 amperes.* *Ratings in excess of 400 amperes shall comply with Table 310.16.* *Table 310.12(A) also applies to feeder conductors supplying the entire load.*	**Minimum Size Conductors**	**18**	2/0 AWG copper 4/0 AWG aluminum

Ⓔ

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Line 19—Neutral Conductor

Ⓐ No neutral conductor is connected to the water heater in this calculation.

Ⓑ All fastened-in-place appliances utilizing a grounded conductor must be included.

Ⓒ The electric heat and air-conditioner compressor are 240-volt loads (no neutral).

Ⓓ If the largest motor is 120 (115) volts, use the motor load in line 14.

Ⓔ For the purpose of this load calculation, the terms **neutral** and **grounded** are synonymous.

Ⓕ The feeder (or service) neutral load is the maximum unbalance of the load determined by Article 220 »*220.61(A)*«.

Ⓖ The neutral (grounded) conductor can be smaller than the ungrounded (hot) conductors provided certain requirements in 215.2, 220.61, and 230.42 are met »*310.12(D)*«.

Ⓗ All numbers are shown as volt-amperes.

Ⓘ Since all of the general lighting and receptacle loads have a rating of 120 volts, the total volt-ampere rating (from line 9) must be included in the neutral calculation.

Ⓙ A demand factor of 75% can be applied to the nameplate rating load of four or more fastened-in-place appliances »*220.53*«.

Ⓚ Multiply the electric clothes dryer load (line 11) by 70% to determine the neutral load »*220.61(B)*«.

Ⓛ Multiplying line 12 by 70% provides the electric cooking appliances neutral load »*220.61(B)*«.

Ⓜ Because both of these motors are energized simultaneously, thereby contributing to the neutral load, they must be included in the neutral calculation.

Ⓝ The total neutral volt-ampere load (21,247) divided by the voltage (240) renders the minimum neutral amperes (89).

Ⓞ Size the neutral by finding the maximum unbalanced load.

Ⓟ A 3 AWG (75°C [167°F]) copper conductor is required for 89 amperes »*Table 310.16*«.

Ⓠ A 2 AWG (75°C [167°F]) aluminum conductor is required for 89 amperes »*Table 310.16*«.

	General lighting and receptacles (line 9)	**7048**	Ⓗ Ⓘ
	Fastened-in-place appliances		
Ⓐ	**Water heater**	**0**	
Ⓑ	**Dishwasher**	**1200**	
	In-sink waste disposer	**1127**	
	Trash compactor	**900**	
	Three attic fans	**1512**	
	Total	**4739**	Ⓙ
	Total fastened-in-place appliances (4739 × 75%)	**3554**	Ⓚ
	Electric Clothes dryer (line 11 × 70%)	**3850**	Ⓛ
	Electric Cooking appliances (line 12 × 70%)	**5915**	
Ⓒ	**Electric heat**	**0**	
	Air-conditioner compressor	**0**	
	Air handler (blower motor)	**368**	Ⓜ
	Condenser fan motor	**230**	
Ⓓ	**Largest motor**	**282**	
	TOTAL	**21,247**	Ⓝ

Ⓔ Ⓕ Ⓖ Ⓞ Ⓟ

19 Size the Neutral Conductor. *220.61* *310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded ("hot") conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	**19**	3 copper 2 aluminum

Ⓠ

Line 20—Grounding Electrode Conductor

Ⓐ Use Table 310.12(A) to find service entrance and service lateral conductors.

Ⓑ The minimum size grounding electrode conductor is 4 AWG copper (or 2 AWG aluminum) »*Table 250.66*«.

Ⓒ In outdoor applications, aluminum (or copper-clad aluminum) grounding electrode conductors must not be installed within 18 in. (450 mm) of the earth »*250.64(A)(3)*«.

Ⓐ Ⓑ Ⓒ

20 Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor**	**20**	4 copper 2 aluminum

The following page shows the completed one-family dwelling load calculation according to the standard method.

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Standard Method Load Calculation for One-Family Dwellings

1 General Lighting and Receptacle Loads *220.41*
Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.
3 × 1855 (sq ft using outside dimensions) = **1** 5565

2 Small-Appliance Branch Circuits *220.52(A)*
At least ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*
1500 × 4 (minimum of two) = **2** 6000

3 Laundry Branch Circuit(s) *220.52(B)*
At least ***one*** *laundry branch circuit must be included. 210.11(C)(2)*
1500 × 2 (minimum of one) = **3** 3000

4 Add lines 1, 2, and 3 **4** 14,565

Lines 5 through 8 utilize the demand factors found in *Table 220.45.*

5 14,565 (line 4) – 3000 = **5** 11,565 (if 117,000 or less, skip to line 8)

6 ---- (line 5, if more than 117,000) – 117,000 = **6** ----

7 ---- (line 6) × 25% = **7** ----

8 11,565 (smaller of line 5 or 117,000) × 35% = **8** 4048

9 Total General Lighting and Receptacle Load 3000 + ---- (line 7) + 4048 (line 8) = **9** 7048

10 Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or greater *220.53*
Use the nameplate rating.
Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.

water heater / 4500
dishwasher / 1200
disposer / 1127
compactor / 900
3 attic fans / 1512
/
/
/
/

If fewer than four units, put total volt-amperes on line 10.
If four or more units, multiply total volt-amperes by 75%.
9239 (volt-amps of four or more) × 75% = **10** 6929

11 Electric Clothes Dryers *220.54*
(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.
The neutral demand load is 70% for services and feeders. *220.61(B)*
11 5500

12 Household Electric Cooking Appliances over 1750 Watts *220.55*
(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.
The neutral demand load is 70% for services and feeders. *220.61(B)*
12 8450

13 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60*
Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.
13 15,368

14 Largest Motor (one motor only) *220.50*, *440.32* through *.35*, and *430.24* through *.26*
Multiply the volt-amperes of the largest motor by 25%.
If 25% of the largest motor is in Line 13, leave Line 14 blank.
1127 (volt-amps of largest motor) × 25% = **14** 282

15 Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.* **15** 43,577

16 Minimum Amperes
Divide the total volt-amperes by the voltage
43,577 (line 15) ÷ 240 (voltage) = **16** 182 (minimum amperes)

17 **Minimum Size Service or Feeder** ***240.6(A)*** **17** 200

18 Size the Service or Feeder Conductors.
Use Table 310.12(A) to find the service conductors up to 400 amperes.
Ratings in excess of 400 amperes shall comply with Table 310.16.
Table 310.12(A) also applies to feeder conductors supplying the entire load.
Minimum Size Conductors **18**
2/0 AWG copper
4/0 AWG aluminum

19 Size the Neutral Conductor. *220.61*
310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded ("hot") conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.
250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).
Minimum Size Neutral Conductor **19**
3 copper
2 aluminum

20 Size the Grounding Electrode Conductor (for Service). *250.66*
Use line 18 to find the grounding electrode conductor in Table 250.66.
Size the Equipment Grounding Conductor (for Feeder). *250.122*
Use line 17 to find the equipment grounding conductor in Table 250.122.
Equipment grounding conductor types are listed in 250.118.
Minimum Size Grounding Electrode Conductor **20**
4 copper
2 aluminum

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Optional Method: One-Family Dwellings

Optional Method Load Calculation for One-Family Dwellings

1 General Lighting and Receptacle Loads *220.82(B)(1)*
Do not include open porches, garages, or unused or unfinished spaces not adaptable for future use.
3 × ________ = **1** ________
(sq ft using outside dimensions)

2 Small-Appliance Branch Circuits *220.82(B)(2)*
At least ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*
1500 × ________ = **2** ________
(minimum of two)

3 Laundry Branch Circuit(s) *220.82(B)(2)*
At least ***one*** *laundry branch circuit must be included. 210.11(C)(2)*
1500 × ________ = **3** ________
(minimum of one)

4 Appliances *220.82(B)(3)* and *(4)*
Use the nameplate rating of ***all*** *appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, ovens, cooktops, motors, water heaters, and clothes dryers. Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.*

Do not include any heating or air-conditioning equipment in this section.

Total volt-amperes of all appliances LISTED BELOW **4** ________

water heater /	clothes dryer /	range /
dishwasher /	disposer /	/
/	/	/
/	/	/
/	/	/

5 Apply *220.82(B)* demand factor to the total of lines 1 through 4.
________ – 10,000 = ________ × 40% = ________ + 10,000 = **5** ________
(total of lines 1 through 4)

6 Heating or Air-Conditioning System *220.82(C)*
Use the nameplate ratings in volt-amperes for all applicable systems in lines ***a*** *through* ***e****.*

a) Air-conditioning and cooling systems, including heat pumps without any supplemental electric heating:
________ × 100% = **a)** ________

b) Electric thermal storage and other heating systems where the usual load is expected to be continuous at full nameplate value. *Systems qualifying under this selection shall not be figured under any other selection in 220.82(C).*
________ × 100% = **b)** ________

c) Supplemental electric heating equipment for heat-pump systems. Include the heat-pump compressor(s) at 100%. *If the heat-pump compressor is prevented from operating with the supplemental heat, omit the compressor.*
________ × 65% = **c)** ________

d) Electric space-heating equipment, if fewer than four separately controlled units:
________ × 65% = **d)** ________

e) Electric space-heating equipment, if four or more separately controlled units:
________ × 40% = **e)** ________

7 Total Volt-Ampere Demand Load:
________ + ________ = **7** ________
(largest VA rating from lines 6a through 6e) (line 5)

8 Minimum Amperes
Divide the total volt-amperes by the voltage.
________ ÷ ________ = **8** ________
(line 7) (voltage) (minimum amperes)

9 **Minimum Size Service or Feeder** ***240.6(A)*** **9** ________
(minimum is 100 amperes)

10 Size the Service or Feeder Conductors.
Use Table 310.12(A) to find the service conductors up to 400 amperes. Ratings in excess of 400 amperes shall comply with Table 310.16. Table 310.12(A) also applies to feeder conductors supplying the entire load.
Minimum Size Conductors **10** ________

11 Size the Neutral Conductor. *220.61*
Note: There is no optional method for calculating the neutral conductor.
310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded ("hot") conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.
250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).
Minimum Size Neutral Conductor **11** ________

12 Size the Grounding Electrode Conductor.
Use line 10 to find the grounding electrode conductor in Table 250.66.
Size the Equipment Grounding Conductor (for Feeder). *250.122*
Use line 9 to find the equipment grounding conductor in Table 250.122.
Equipment grounding conductor types are listed in 250.118.
Minimum Size Grounding Electrode Conductor **12** ________

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Lines 1 through 3—General Lighting and Receptacle Loads

Ⓐ In the **optional method,** lines 1, 2, and 3 are calculated exactly as described in the **standard method.** (See explanations on pages 168 and 169.)

Ⓐ

1	General Lighting and Receptacle Loads *220.82(B)(1)* *Do not include open porches, garages, or unused or unfinished spaces not adaptable for future use.*	3 ×	1855 (sq ft using outside dimensions)	=	1	5565
2	Small-Appliance Branch Circuits *220.82(B)(2)* *At least **two** small-appliance branch circuits must be included. 210.11(C)(1)*	1500 ×	4 (minimum of two)	=	2	6000
3	Laundry Branch Circuit(s) *220.82(B)(2)* *At least **one** laundry branch circuit must be included. 210.11(C)(2)*	1500 ×	2 (minimum of one)	=	3	3000

Line 4—Appliances

Ⓐ This section includes appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and water heaters »*220.82(B)(3)*«. Include all permanently connected motors not already included »*220.82(B)(4)*«.

Ⓑ Heating and air-conditioning systems are *not* included in this calculation.

Ⓒ Use the exact nameplate rating of the clothes dryer, even if less than 5000 volt-amperes.

Ⓓ Do not apply the demand factors in Table 220.55 to household electric cooking appliance (ranges, cooktops, and ovens). List the nameplate ratings as they appear.

Ⓐ Ⓑ Ⓒ

4	Appliances *220.82(B)(3)* and *(4)* *Use the nameplate rating of **all** appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, ovens, cooktops, motors, water heaters, and clothes dryers. Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.*	*Do not include any heating or air-conditioning equipment in this section.*	Total volt-amperes of all appliances LISTED BELOW	4 27,739
	water heater / 4500	clothes dryer / 5500	range /	
	dishwasher / 1200	disposer / 1127	cooktop / 7000	
	compactor / 900	3 attic fans / 1512	oven / 6000	
	/	/	/	
	/	/	/	

Ⓓ

Line 5—Applying Demand Factors to the Total of Lines 1 through 4

Ⓐ This demand factor is found in 220.82(B).

Ⓑ This is the newly calculated load including everything except the heating and air-conditioning systems.

Ⓒ (5565 + 6000 + 3000 + 27,739)

Ⓓ Because the first 10,000 volt-amperes are calculated at 100%, subtract 10,000 here.

Ⓔ The remainder of the load is calculated at 40%.

Ⓕ The result on line 5 has been rounded up from 12,921.6.

Ⓐ Ⓑ

5	Apply *220.82(B)* demand factor to the total of lines 1 through 4.							
	42,304 (total of lines 1 through 4)	– 10,000 =	32,304	× 40% =	12,922	+ 10,000 =	5	22,922

Ⓒ Ⓓ Ⓔ Ⓕ

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Line 6—Heating or Air-Conditioning Systems

Ⓐ The air-conditioner compressor (16.6 × 230 = 3818 VA), condenser fan motor (2 × 115 = 230 VA), and blower motor (3.2 × 115 = 368 VA) have a combined load of 4416 volt-amperes.

Ⓑ The electric heat (3 × 5000 = 15,000) added to the blower motor (3.2 × 115 = 368) is 15,368 volt-amperes.

Note

The total volt-ampere rating of one, two, or three separately controlled heating units is multiplied by 65%. The total volt-ampere rating of four (or more) separately controlled heating units is multiplied by 40%.

Ⓐ Ⓑ

6 Heating or Air-Conditioning System *220.82(C)* *Use the nameplate ratings in volt-amperes for all applicable systems in lines* ***a*** *through* ***e****.*		**c)** Supplemental electric heating equipment for heat-pump systems. Include the heat-pump compressor(s) at 100%. *If the heat-pump compressor is prevented from operating with the supplemental heat, omit the compressor.* ________ × 65% =	**c)**
a) Air-conditioning and cooling systems, including heat pumps without any supplemental electric heating: 4416 × 100% =	**a)** 4416	**d)** Electric space-heating equipment, if fewer than four separately controlled units: 15,368 × 65% =	**d)** 9989
b) Electric thermal storage and other heating systems where the usual load is expected to be continuous at full nameplate value. *Systems qualifying under this selection shall not be figured under any other selection in 220.82(C).* ________ × 100% =	**b)**	**e)** Electric space-heating equipment, if four or more separately controlled units: ________ × 40% =	**e)**

Line 7—Total Volt-Ampere Demand Load

Ⓐ The largest volt-ampere rating of the heating or air-conditioning system(s), after application of demand factors.

Ⓑ The volt-ampere demand load from line 5.

Ⓒ The total volt-ampere load calculated by the optional method. (For comparison, this one-family dwelling, calculated by the standard method, is 43,577 volt-amperes.)

Ⓐ Ⓑ Ⓒ

7 Total Volt-Ampere Demand Load:	9989 (largest VA rating from lines 6a through 6e)	+	22,922 (line 5)	=	**7**	32,911

Lines 8 and 9—Minimum Service or Feeder

Ⓐ The volt-ampere load from line 7

Ⓑ The source voltage

Ⓒ The fraction of an ampere (0.13) has been dropped.

Ⓓ The overcurrent protection chosen for the service (or feeder) must be higher than the number found on line 8.

Standard ampere ratings for fuses and circuit breakers are listed in 240.6(A).

Ⓔ The next standard size fuse or breaker above 137 amperes is 150. (By the standard method, this same dwelling requires a 200-ampere service.)

Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

8 Minimum Amperes *Divide the total volt-amperes by the voltage.*	32,911 (line 7)	÷	240 (voltage)	=	**8**	137 (minimum amperes)	**9** **Minimum Size Service or Feeder** ***240.6(A)***	**9**	150 (minimum is 100 amperes)

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Line 10—Minimum Size Conductors

A For a service rated 100 through 400 A, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83% of the service rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied »*310.12(A)* and *Table 310.12(A)*«.

B Table 310.12(A) also applies to feeder conductors that supply the entire load associated with a one-family dwelling »*310.12(B)*«.

C The maximum service or feeder rating permitted when using Table 310.12(A) is 400 amperes.

D In the 75°C (167°F) of Table 310.16, the size copper conductor required for 200 amps is 3/0 AWG. However, since this is a dwelling service, select the conductor from Table 310.12(A). The minimum size copper conductor is 2/0 AWG »*Table 310.12(A)*«.

E Table 310.12(A) provides sizes for both copper and aluminum conductors. Copper-clad aluminum conductors are listed in the column with aluminum.

A **B** **C** **D**

10 Size the Service or Feeder Conductors. *Use Table 310.12(A) to find the service conductors up to 400 amperes.* *Ratings in excess of 400 amperes shall comply with Table 310.16.* *Table 310.12(A) also applies to feeder conductors supplying the entire load.*	**Minimum Size Conductors**	**10**	1 copper 2/0 AWG aluminum

E

Line 11—Neutral Conductor

A The neutral conductor must be calculated by the standard method.

B Review the complete neutral conductor explanation on page 173, since the calculation method is the same.

> **Note**
>
> There is no optional method for calculating the neutral conductor.

A **B**

11 Size the Neutral Conductor. *220.61* **Note: There is no optional method for calculating the neutral conductor.** *310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded ("hot") conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	**11**	3 copper 2 aluminum

Line 12—Grounding Electrode Conductor

A The minimum size grounding electrode conductor is 6 AWG copper (or 4 AWG aluminum) »*Table 250.66*«.

A

12 Size the Grounding Electrode Conductor. *Use line 10 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 9 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor**	**12**	6 copper 4 aluminum

The following page shows the completed one-family dwelling load calculation according to the optional method.

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Optional Method Load Calculation for One-Family Dwellings

1 General Lighting and Receptacle Loads *220.82(B)(1)*
Do not include open porches, garages, or unused or unfinished spaces not adaptable for future use.
3 × 1855 (sq ft using outside dimensions) = **1** 5565

2 Small-Appliance Branch Circuits *220.82(B)(2)*
At least ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*
1500 × 4 (minimum of two) = **2** 6000

3 Laundry Branch Circuit(s) *220.82(B)(2)*
At least ***one*** *laundry branch circuit must be included. 210.11(C)(2)*
1500 × 2 (minimum of one) = **3** 3000

4 Appliances *220.82(B)(3)* and *(4)*
Use the nameplate rating of ***all*** *appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, ovens, cooktops, motors, water heaters, and clothes dryers. Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.*

Do not include any heating or air-conditioning equipment in this section.

Total volt-amperes of all appliances LISTED BELOW **4** 27,739

water heater / 4500	clothes dryer / 5500	range /
dishwasher / 1200	disposer / 1127	cooktop / 7000
compactor / 900	3 attic fans / 1512	oven / 6000
/	/	/
/	/	/

5 Apply *220.82(B)* demand factor to the total of lines 1 through 4.
42,304 (total of lines 1 through 4) – 10,000 = 32,304 × 40% = 12,922 + 10,000 = **5** 22,922

6 Heating or Air-Conditioning System *220.82(C)*
Use the nameplate ratings in volt-amperes for all applicable systems in lines ***a*** *through* ***e****.*

a) Air-conditioning and cooling systems, including heat pumps without any supplemental electric heating:
4416 × 100% = **a)** 4416

b) Electric thermal storage and other heating systems where the usual load is expected to be continuous at full nameplate value. *Systems qualifying under this selection shall not be figured under any other selection in 220.82(C).*
× 100% = **b)**

c) Supplemental electric heating equipment for heat-pump systems. Include the heat-pump compressor(s) at 100%. *If the heat-pump compressor is prevented from operating with the supplemental heat, omit the compressor.*
× 65% = **c)**

d) Electric space-heating equipment, if fewer than four separately controlled units:
15,368 × 65% = **d)** 9989

e) Electric space-heating equipment, if four or more separately controlled units:
× 40% = **e)**

7 Total Volt-Ampere Demand Load:
9989 (largest VA rating from lines 6a through 6e) + 22,922 (line 5) = **7** 32,911

8 Minimum Amperes
Divide the total volt-amperes by the voltage.
32,911 (line 7) ÷ 240 (voltage) = **8** 137 (minimum amperes)

9 **Minimum Size Service or Feeder *240.6(A)*** **9** 150 (minimum is 100 amperes)

10 Size the Service or Feeder Conductors.
Use Table 310.12(A) to find the service conductors up to 400 amperes. Ratings in excess of 400 amperes shall comply with Table 310.16. Table 310.12(A) also applies to feeder conductors supplying the entire load.
Minimum Size Conductors **10** 1 copper
2/0 AWG aluminum

11 Size the Neutral Conductor. *220.61*
Note: There is no optional method for calculating the neutral conductor.
310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded ("hot") conductors, provided the requirements of 215.2, 220.61, and 230.42 are met. 250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).
Minimum Size Neutral Conductor **11** 3 copper
2 aluminum

12 Size the Grounding Electrode Conductor.
Use line 10 to find the grounding electrode conductor in Table 250.66.
Size the Equipment Grounding Conductor (for Feeder). *250.122*
Use line 9 to find the equipment grounding conductor in Table 250.122. Equipment grounding conductor types are listed in 250.118.
Minimum Size Grounding Electrode Conductor **12** 6 copper
4 aluminum

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Summary

- A dwelling unit load calculation, for general lighting and receptacles, is determined by total square footage.
- Section 220.41 requires a unit load of 3 volt-amperes per square foot.
- At least one laundry and two small-appliance branch circuits are required when performing a service (or main power feeder) calculation.
- Laundry and small-appliance branch circuits are calculated using a rating of at least 1500 volt-amperes each.
- Table 220.45 demand factors are applied to the general lighting, small appliance, and laundry loads.
- The total volt-ampere rating of four or more fastened-in-place appliances rated ¼ hp or greater or 500 watts or greater is multiplied by 75%.
- Demand loads for household cooking appliances (over 1¾ kW rating) are found in Table 220.55.
- The heating and air-conditioning loads are compared, and the larger of the two is used.
- For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.
- Two load calculation methods are provided in Article 220, standard and optional.
- The neutral conductor can be smaller than the ungrounded (hot) conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.
- Table 250.66 is used to size grounding electrode conductors.

Unit 8 Competency Test

NEC® Reference	Answer	
____________	____________	1. It shall be permissible to apply a demand factor of ____________% to the nameplate rating load of ____________ or more appliances fastened in place rated ¼ hp or greater or 500 watts or greater, other than electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment, that are served by the same feeder in a one-family dwelling.
____________	____________	2. What is the lighting load (before applying demand factors) for a dwelling unit with outside dimensions of 30 ft × 48 ft on the first floor and 22 ft × 42 ft on the second floor?
____________	____________	3. A homeowner wants to add twelve general-purpose receptacle outlets to the electrical drawings before the house is built. What additional load, in volt-amperes, will they add to the service-load calculation?
____________	____________	4. In each dwelling unit, the feeder load shall be calculated at ____________ volt-amperes for each 2-wire small-appliance branch circuit required by 210.11(C)(1).
____________	____________	5. What is the minimum calculated service load for two 3½-kW wall-mounted ovens and one 5-kW counter-mounted cooking unit? All of the appliances are supplied from a single branch circuit and are located in the same room of a one-family dwelling. a) 12 kW b) 9.6 kW c) 8 kW d) 6.6 kW
____________	____________	6. A 4.5-kVA, 240-volt electric clothes dryer contributes ____________ amperes to the neutral load, when calculating the service by the standard method.
____________	____________	7. A one-family dwelling contains the following appliances: a 1-kVA, 115-volt dishwasher; a ¼-horsepower, 115-volt in-sink waste disposer; and a ⅓-horsepower, 115-volt trash compactor. Using the standard method, what is the calculated service load, in volt-amperes, for these appliances? None of these motors will be the largest motor in this dwelling unit.
____________	____________	8. For one-family dwellings, the service disconnecting means must have a rating of at least ____________ amperes, 3-wire.
____________	____________	9. A one-family dwelling has a 175-ampere, 240-volt service that is fed with 75°C (167°F) conductors. What is the minimum size copper grounding electrode conductor required?

***NEC*® Reference** **Answer**

___________ ___________ 10. A one-family dwelling has six 3-kW electric wall heaters (with individual thermostats) and five room air conditioners. Two air conditioners are rated 10.5 amperes at 230 volts, and the other three are rated 7.2 amperes at 115 volts. A service calculation is being performed, using the optional method. How many volt-amperes should be included (after demand factors) for the heating and air conditioning? (Assume heater kW ratings equivalent to kVA.)

___________ ___________ 11. In each dwelling unit, a feeder load of at least ___________ volt-amperes must be included for each 2-wire laundry branch circuit installed as required by 210.11(C)(2).

___________ ___________ 12. A 12-kW, 240-volt range contributes ___________ watts to the load when calculating the service by the standard method.

Questions 13 through 21 are based on a 120/240-volt, 3-wire, single-phase one-family dwelling containing the following:

Floor area	2500 ft^2	Electric clothes dryer	4 kW, 240-volt
Range	12 kW, 240-volt	Electric heat (two banks at 3 kW each)	6 kW, 240-volt
Water heater	4 kW, 240-volt	Air handler (blower motor)	¼ hp, 115-volt
Dishwasher	1.5 kW, 120-volt	Air-conditioner compressor	5 hp, 230-volt
In-sink waste disposer	⅓ hp, 115-volt	Condenser fan motor	⅙ hp, 115-volt

Assume water heater, clothes dryer, range, and electric heat kW ratings equivalent to kVA.

Using Part III (the standard method) of Article 220:

___________ ___________ 13. What is the minimum ampere rating for the service?

___________ ___________ 14. What is the minimum size service?

___________ ___________ 15. What is the minimum size THWN copper conductor that can be installed as the service (ungrounded) conductor?

___________ ___________ 16. What is the minimum size grounding electrode conductor?

Using Part IV (the optional method) of Article 220:

___________ ___________ 17. What is the minimum ampere rating for the service?

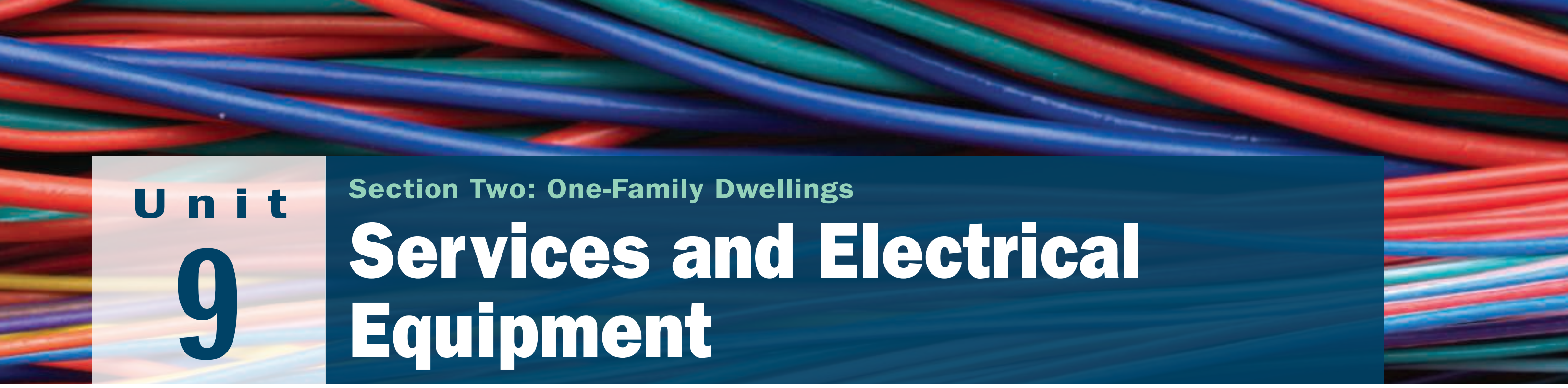
___________ ___________ 18. What is the minimum size service?

___________ ___________ 19. What is the minimum size THWN copper conductor that can be installed as the service (ungrounded) conductor?

___________ ___________ 20. What is the minimum size grounding electrode conductor?

Finding the Neutral Load:

___________ ___________ 21. What is the minimum size THWN copper conductor that can be installed as the neutral conductor?



Section Two: One-Family Dwellings

Unit 9

Services and Electrical Equipment

Objectives

After studying this unit, the student should be able to:

- determine adequate strength for a mast supporting service-drop conductors.
- explain service-entrance cable provisions.
- define a service lateral and understand the applicable provisions.
- summarize minimum wiring clearance requirements (vertical, horizontal, etc.) for service and outside wiring.
- recall working space required around service equipment, panelboards, electric equipment, etc.
- explain in detail panelboards, cabinets, and cutout boxes.
- summarize the multitude of provisions relating to circuit breakers and fuses.
- explain different aspects of service equipment and panelboard installations.
- recall how to select conductor sizes in accordance with Table 310.12(A).
- clarify the requirements for marking an emergency disconnect at one- and two-family dwelling units.
- explain in detail grounding and bonding procedures.
- describe grounded and grounding conductor terminations in remote panelboards (subpanels).
- summarize the grounding system as a whole.
- explain how to ground and bond panelboards on the supply side, as well as the load side of the service disconnecting means.
- clarify how to prevent objectionable current flow in grounding conductors.
- recall the grounding requirements for panelboards installed in separate buildings or structures.

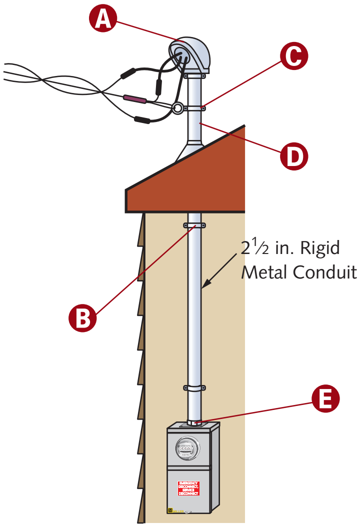
Introduction

Because the service is the heart of the electrical system, the importance of understanding this unit is enormous. Many of the regulations learned in this unit are applicable in all types of occupancies, not merely single-family dwellings. Unit 9 is divided into five sections. The first, "Service-Entrance Wiring Methods," addresses both overhead and underground service entrance provisions. The section entitled "Service and Outside Wiring Clearances" covers the clearances required above roofs and final grade. Other clearances (horizontal, vertical, and diagonal) are shown for windows, doors, balconies, platforms, etc. Next, the "Working Space around Equipment" section illustrates common working space requirements. "Service Equipment and Panelboards" explains panelboards, cutout boxes, and cabinets. Specific provisions pertaining to circuit breakers, fuses, and circuit breaker panels are also covered. "Grounding," the last section, explains in detail Article 250 provisions relating to service equipment and panelboards. Refer to Unit 9 often when studying (or installing) services, whether one-family or multifamily dwellings, or commercial and even industrial buildings.

Since many local jurisdictions and electric utility companies have supplemental requirements, exercise caution in compiling a complete set of service installation requirements. Examples of these requirements include, but are not limited to, restrictions on the type of conduit used for service mast; minimum conduit trade size; specific strapping methods; restrictions on the use of service-entrance cables; special underground service provisions; limitations on the maximum distance service-entrance conductors can run within a building or structure; and various grounding provisions. Obtain a copy of these additional rules (if any) for your area.

Service-Entrance Wiring Methods

Service Mast as Support



Ⓐ Service-entrance and overhead service conductors shall be arranged so that water shall not enter the service raceway or equipment »*230.54(G)*«.

Ⓑ It is not required (where approved) that rigid (and intermediate) metal conduit be securely fastened within 3 ft (900 mm) of the service head for above-the-roof termination of a mast »*342.30(A)(3)* and *344.30(A)(3)*«.

Ⓒ Open conductors must be attached to fittings identified for use with service conductors or to noncombustible, nonabsorbent insulators securely attached to the building or other structure »*230.27*«.

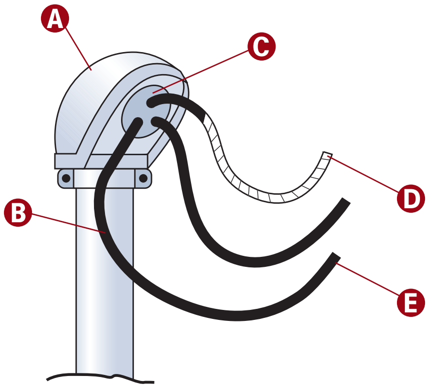
Ⓓ The service mast shall be of adequate strength or be supported by braces or guys to withstand safely the strain imposed by the service-drop or overhead service conductors »*230.28(A)*«.

Ⓔ Hubs intended for use with a conduit that serves as a service mast shall be identified for use with service-entrance equipment »*230.28(A)*«.

Caution

Service-drop or overhead service conductors shall not be attached to a service mast between a weatherhead or the end of the conduit and a coupling, where the coupling is located above the last point of securement to the building or other structure or is located above the building or other structure »*230.28(B)*«.

Service Heads (Weather Heads)



Ⓐ Service raceways must be equipped with a service head at the point of connection to service-drop or overhead service conductors. The service head shall be listed for use in wet locations »*230.54(A)*«.

Ⓑ Service-entrance and overhead service conductors shall be arranged so that water shall not enter the service raceway or equipment »*230.54(G)*«.

Ⓒ Conductors of different potential must be brought out of service heads through separately bushed openings »*230.54(E)*«.

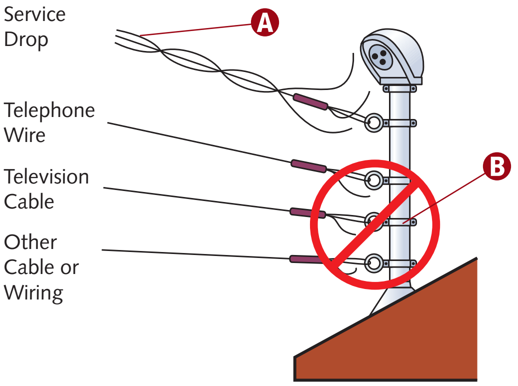
Ⓓ An insulated grounded conductor 4 AWG or larger must be identified either by a continuous white or gray outer finish or by three continuous white or gray stripes on other than green insulation along its entire length or by a distinctive white or gray marking at its terminations during installation. This marking must completely encircle the conductor or insulation »*200.6(B)*«.

Ⓔ Conductors must have adequate mechanical strength and sufficient ampacity to carry the current for the load (as computed in accordance with Article 220) »*230.23(A)*«.

Service Mast Attachments

Ⓐ Service drop is defined as the overhead conductors between the serving utility and the service point »*Article 100*«.

Ⓑ Nothing except power service-drop or overhead service conductors can be attached to the service mast »*230.28*«.



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Service Drops Attached to Buildings

A Open conductors must be attached to fittings identified for use with service conductors, or to noncombustible, nonabsorbent insulators that are securely attached to the building (or other structure) »*230.27*«.

B Electrical metallic tubing (EMT) couplings and connectors shall be made up tight. If installed in wet locations, they shall be listed for use in wet locations »*358.42* and *314.15*«.

C Service heads on raceways or service-entrance cables must be located above the point where service-drop or overhead service conductors are attached to the building or other structure »*230.54(C)*«.

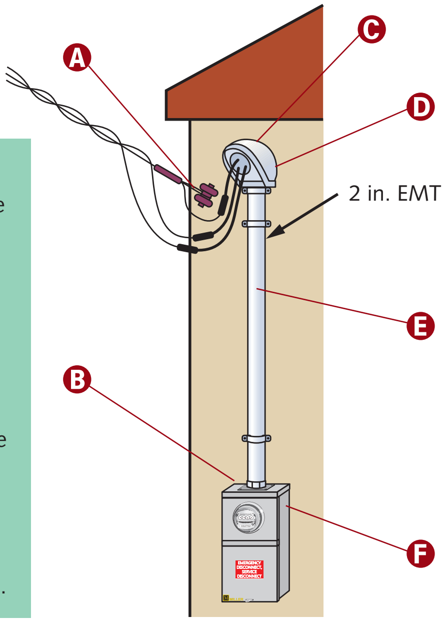
D Where it is impracticable to locate the service head above the point of attachment, the service head must be located within 24 in. (600 mm) of that point »*230.54(C) Exception*«.

E Because this service mast does not support service-drop conductors, another wiring method (EMT) is used. Other allowable service-entrance methods for 1000 volts, nominal, or less are listed in 230.43.

F Electric equipment must be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, etc., are not acceptable »*110.13(A)*«.

Note

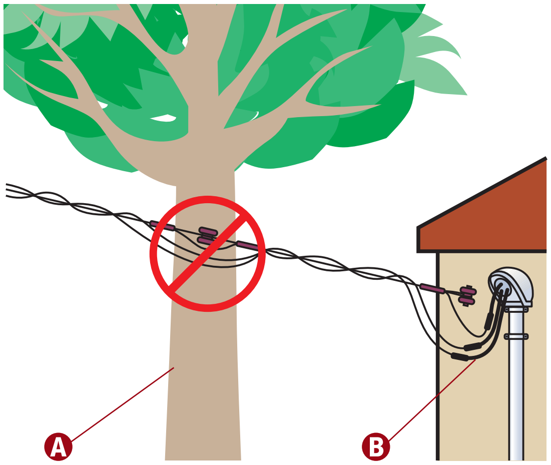
Overhead service conductors are defined as the overhead conductors between the service point and the first point of connection to the service-entrance conductors at the building or other structure »***Article 100***«.



Support of Overhead Conductors

A Vegetation such as trees shall not be used for support of overhead service conductors, service equipment, or other overhead conductor spans »*230.10* and *225.26*«.

B Drip loops must be formed on each individual conductor. To prevent moisture penetration, service-entrance conductors are connected to the service-drop or overhead service conductors either (1) below the level of the service head or (2) below the level of the termination of the service-entrance cable sheath »*230.54(F)*«.



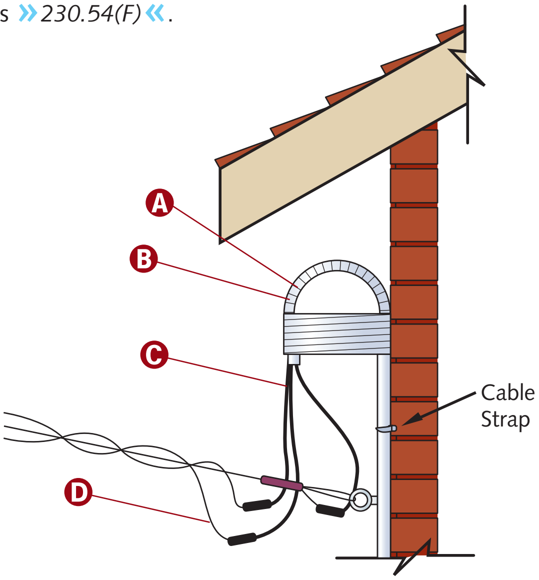
Goosenecks in Service-Entrance Cables

A Bends in service-entrance cable must be made so that the cable is not damaged. In addition, the radius of the curve of the inner edge of any bend must be at least five times the diameter of the cable »*338.24*«.

B Goosenecks in service-entrance cables must be located above the point of attachment of the service-drop or overhead service conductors to the building (or other structure) »*230.54(C)*«.

C Type SE cable can be formed in a gooseneck and taped with a self-sealing weather-resistant thermoplastic »*230.54(B) Exception*«.

D Drip loops must be formed on all individual conductors »*230.54(F)*«.



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Service-Entrance Cable

Ⓐ Service-entrance cables must be fitted with a raintight service head, except for Type SE cable that has been formed into a gooseneck and taped with a self-sealing, weather-resistant thermoplastic *»230.54(B)«*.

Ⓑ If Type SE or USE cable consists of at least two conductors, one can be uninsulated *»338.100(B)«*.

Ⓒ Service-entrance cable is a single conductor or multiconductor cable provided with an overall covering and primarily used for services. Type SE has a flame-retardant, moisture-resistant covering *»Article 100«*.

Ⓓ Service-entrance cables must be held securely in place *»230.54(D)«*.

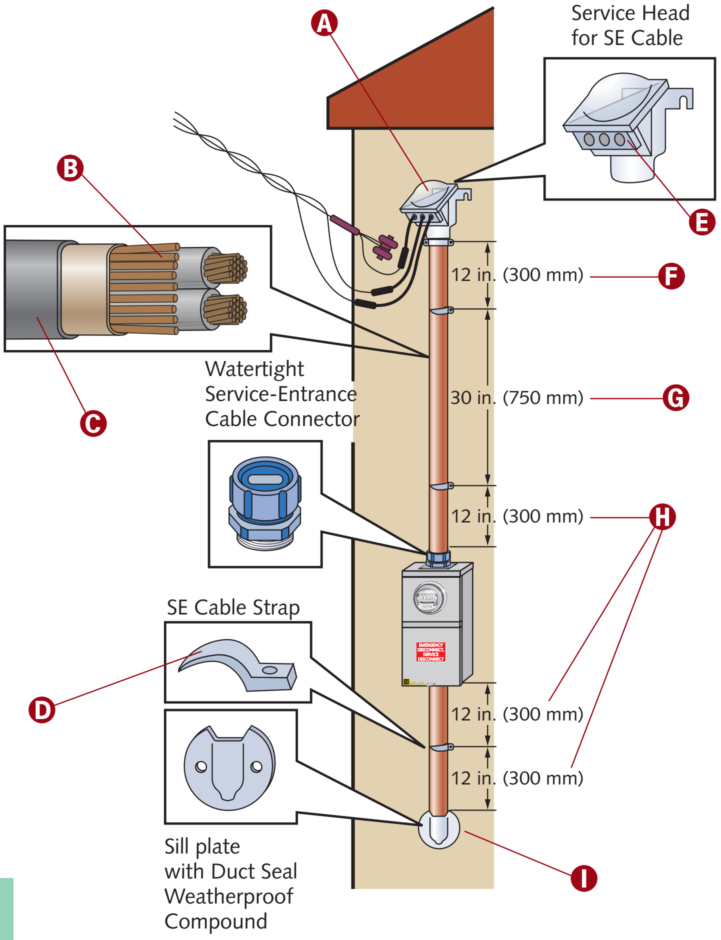
Ⓔ Service head conductors of different potential must be brought out through separately bushed openings *»230.54(E)«*.

Ⓕ Service-entrance cables must be supported by straps (or other approved means) within 12 in. (300 mm) of every service head or gooseneck *»230.51(A)«*.

Ⓖ Entrance cables must be supported at intervals not to exceed 30 in. (750 mm) *»230.51(A)«*.

Ⓗ Entrance cables must be supported within 12 in. (300 mm) of every raceway or enclosure connection *»230.51(A)«*.

Ⓘ Service-entrance and overhead service conductors must be arranged so that water will not enter service raceway or equipment *»230.54(G)«*.


Ⓐ
Service Head for SE Cable
Ⓑ
Ⓔ
12 in. (300 mm)
Ⓕ
Ⓒ
Watertight Service-Entrance Cable Connector
30 in. (750 mm)
Ⓖ
12 in. (300 mm)
Ⓗ
SE Cable Strap
Ⓓ
12 in. (300 mm)
12 in. (300 mm)
Sill plate with Duct Seal Weatherproof Compound
Ⓘ

Note

Type SE and USE cables and associated fittings shall be listed **»338.6«**.

Note

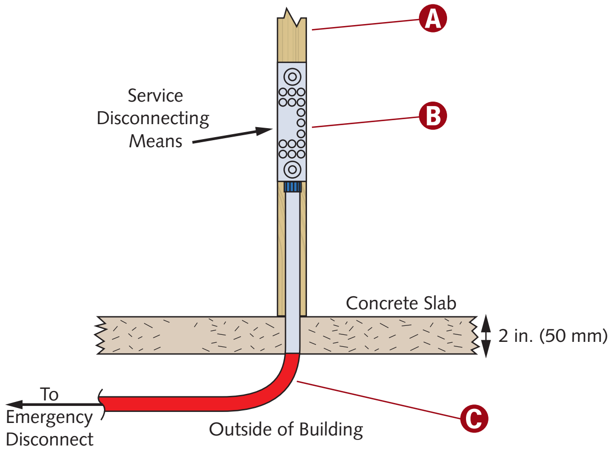
Where subject to physical damage, service cables must be appropriately protected **»230.50«**.

Conductors Considered Outside of a Building

Ⓐ Building or structure interior wall

Ⓑ An interior service disconnecting means must be installed as close as possible to the point of entrance of the service conductors and must be readily accessible. A raceway beneath a 2-in. (50-mm) concrete slab lies outside the building. Under this condition, the service disconnecting means could be installed on (or in) an interior wall of the building. (See Caution.)

Ⓒ Conductors installed under 2 in. (50 mm) or more of concrete beneath a building (or other structure) are considered outside *»230.6(1)«*.


Ⓐ
Service Disconnecting Means
Ⓑ
Concrete Slab
2 in. (50 mm)
To Emergency Disconnect
Outside of Building
Ⓒ

Caution

For one- and two-family dwelling units, the service disconnecting means or emergency meter disconnect(s) must be located outdoors in a readily accessible location *»230.85«*.

Caution

Although not stipulated in the *NEC*®, some local jurisdictions have adopted specific distance requirements for service conductors. (For example, the length for each service conductor between the meter socket enclosure and the service disconnecting means could be limited to only 6 ft [1.8 m].)

Underground Services

Ⓐ Underground service conductors shall be insulated for the applied voltage »*230.30(A)*«. Grounded conductors qualifying under 230.30(A) Exception can be uninsulated (bare).

Ⓑ Metal raceways containing service conductors must be connected to the grounded system conductor if the electrical system is grounded »*250.80*«.

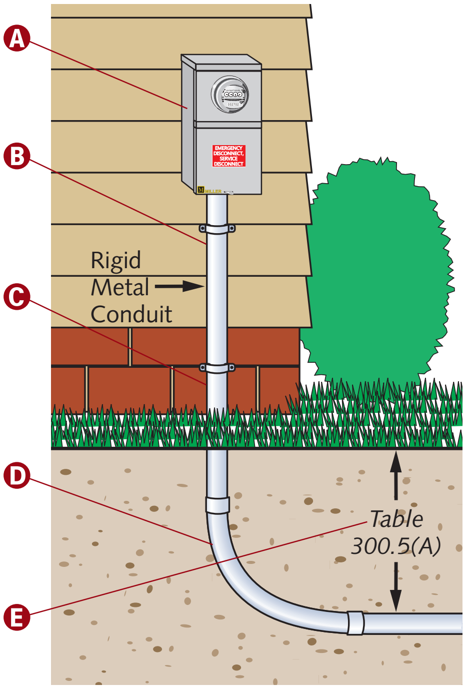
Ⓒ Wiring methods permitted for services of 1000 volts, nominal, or less are listed in 230.43.

Ⓓ Underground service conductors are defined as the underground conductors between the service point and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure, inside or outside the building wall »*Article 100*«. Where there is no terminal box, meter, or other enclosure, the point of connection is considered to be the point of entrance of the service conductors into the building »*Informational Note to Service Conductors, Underground*«.

Ⓔ Direct-buried conduit (or other raceways) must be installed in adherence with Table 300.5(A) minimum cover requirements »*300.5(A)*«.

Note

Underground service conductors must have sufficient ampacity to carry the current for the load (as calculated in accordance with Article 220) »***230.31(A)***«.



Underground Service-Entrance Cable

Although Type USE cable identified for underground use has a moisture-resistant covering, a flame-retardant covering is not required »*Article 100*«.

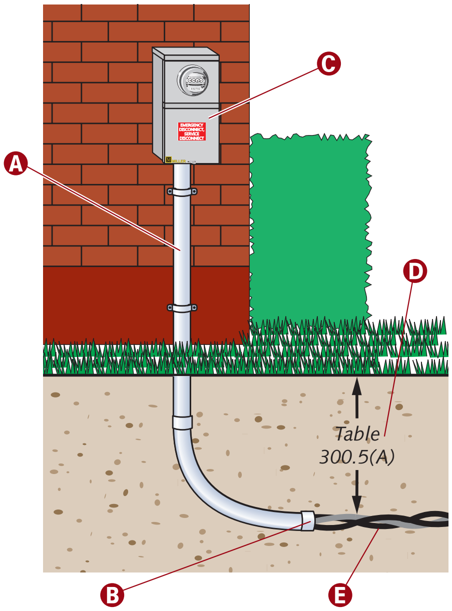
If Type USE cable contains at least two conductors, one can be uninsulated »*338.100(B)*«.

Ⓐ Underground service conductors must be protected against damage in accordance with 300.5. Service conductors entering a building or other structure must be installed in accordance with 230.6 or must be protected by an approved raceway wiring method identified in 230.43 »*230.32*«.

Ⓑ Where the conductors or cables emerge as a direct-burial wiring method, a bushing (or fitting) must be installed to protect conductors from abrasion on the end of the conduit (or tubing) that terminates underground. A seal providing the same level of protection can be used instead of a bushing »*300.5(H)* and *300.15(C)*«.

Ⓒ Type USE cable used for service laterals can emerge aboveground at outside terminations (in meter bases or other enclosures) provided 300.5(D) protection requirements are met »*338.12(B)(2)*«.

Ⓓ When installed, direct-buried cable must meet Table 300.5(A) minimum cover requirements »*300.5(A)*«.



Ⓔ Cabled assemblies of multiple single-conductor Type USE conductors shall be permitted for direct burial. All conductors shall be insulated. Type SE or USE cable with an overall covering containing two or more conductors shall be permitted to have one conductor uninsulated »*338.100*«.

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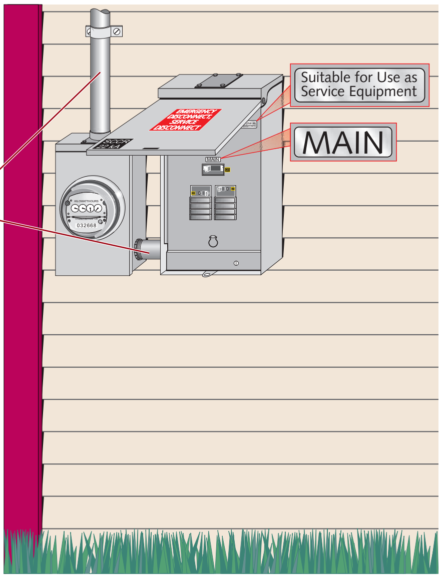
Wiring Methods

Ⓐ Service-entrance conductors must be installed according to applicable *Code* requirements for the type of wiring method used and limited to the following methods: (1) open wiring on insulators; (2) Type IGS cable; (3) rigid metal conduit (RMC); (4) intermediate metal conduit (IMC); (5) electrical metallic tubing (EMT); (6) electrical nonmetallic tubing (ENT); (7) service-entrance cables; (8) wireways; (9) busways; (10) auxiliary gutters; (11) rigid polyvinyl chloride conduit (PVC); (12) cablebus; (13) Type MC cable; (14) mineral-insulated, metal-sheathed cable, Type MI; (15) flexible metal conduit (FMC) or liquidtight flexible metal conduit (LFMC) not longer than 6 ft (1.8 m) between raceways, or between raceway and service equipment, with a supply-side bonding jumper routed with the FMC or LFMC according to 250.102(A), (B), (C), and (E) provisions; (16) liquidtight flexible nonmetallic conduit (LFNC); (17) high-density polyethylene conduit (HDPE); (18) nonmetallic underground conduit with conductors (NUCC); (19) reinforced thermosetting resin conduit (RTRC); (20) Type TC ER cable, or (21) Flexible bus systems »*230.43*«.


Suitable for Use as Service Equipment
MAIN
A

Note

The wiring method of choice must be installed according to provisions for that particular method. For example, Type rigid metal conduit (RMC) must be installed according to Article 344 provisions.

Service and Outside Wiring Clearances

Accessibility to Pedestrians

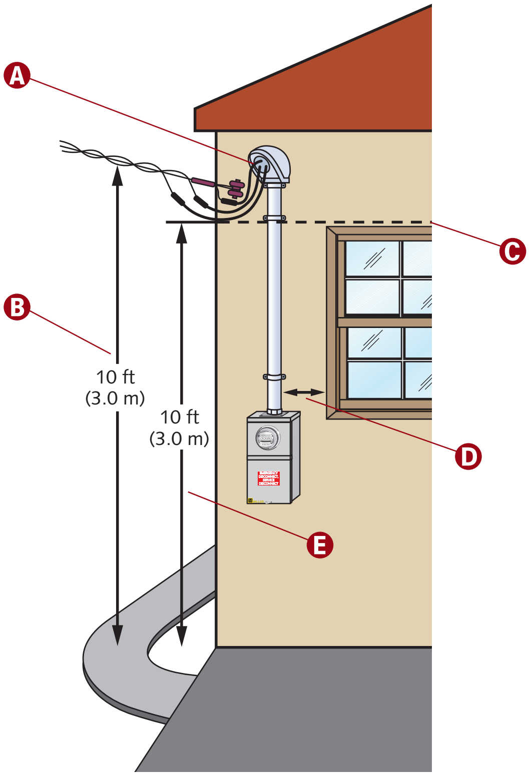
Ⓐ The point of attachment of the overhead service conductors to a building (or other structure) must meet 230.9 and 230.24 minimum clearances. In all cases, this point of attachment must be at least 10 ft (3.0 m) above finished grade »*230.26*«.

Ⓑ Overhead service conductors, accessible only to pedestrian traffic, must have a minimum 10-ft (3.0-m) vertical clearance above finished grade, sidewalks, platforms, or projections that will permit personal contact. The voltage must not exceed 150 to ground »*230.24(B)(1)* and *225.18(1)*«.

Ⓒ The 3-ft (900-mm) minimum requirement does not apply to conductors run above the top level of a window »*230.9(A) Exception* and *225.19(D)(1) Exception*«.

Ⓓ The 3-ft (900-mm) clearance from windows found in 230.9 does not apply to raceways and service equipment.

Ⓔ A drip loop's lowest point must have a minimum vertical clearance of 10 ft (3.0 m) »*230.24(B)(1)* and *225.18(1)*«.



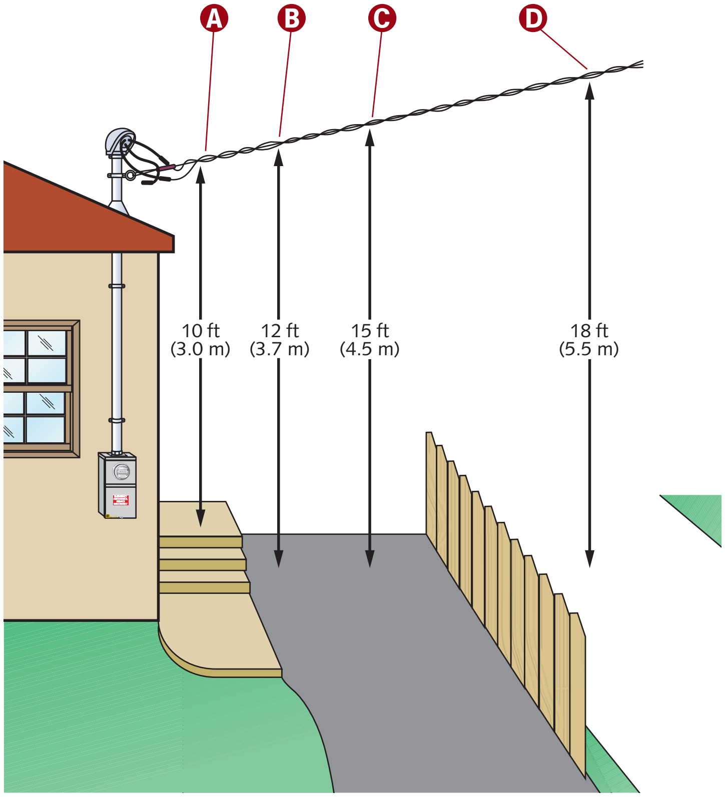
Vertical Clearances

A A 10-ft (3.0-m) minimum vertical clearance is required from any platform or projection from which overhead conductors (of 150 volts, or less, to ground) will permit personal contact »*230.24(B)(1)* and *225.18(1)*«.

B A minimum 12-ft (3.7-m) vertical clearance is required over residential property and driveways, and over commercial areas (not subject to truck traffic) provided conductor voltage does not exceed 300 volts to ground »*230.24(B)(2)* and *225.18(2)*«.

C Conductor voltage exceeding 300 volts to ground has a minimum vertical clearance of 15 ft (4.5 m) »*230.24(B)(3)* and *225.18(3)*«.

D Public streets, alleys, roads, parking areas subject to truck traffic, driveways on nonresidential property, and other land traversed by vehicles (such as cultivated, grazing, forest, and orchard) require a minimum 18-ft (5.5-m) vertical clearance »*230.24(B)(4)* and *225.18(4)*«.



Note

Swimming pool overhead conductor clearances are listed in 680.9.

Caution

A 24½ ft (37.5 m) minimum vertical clearance is required over tracks of railroads »*230.24(B)(5)* and *225.18(5)*«.

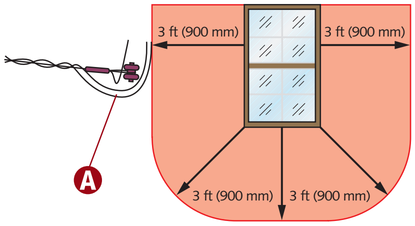
Clearance from Windows and Accessible Areas

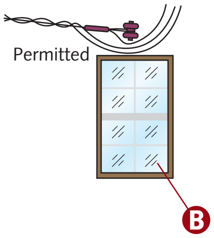
A Service conductors installed as open conductors or multiconductor cable (having no overall outer jacket) must have a clearance of at least 3 ft (900 mm) from windows (designed to open), doors, porches, balconies, ladders, stairs, fire escapes, and similar locations »*230.9(A)* and *225.19(D)(1)*«.

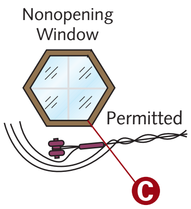
B The 3-ft (900-mm) clearance requirement does not apply to conductors run above the top level of a window »*230.9(A) Exception* and *225.19(D)(1) Exception*«.

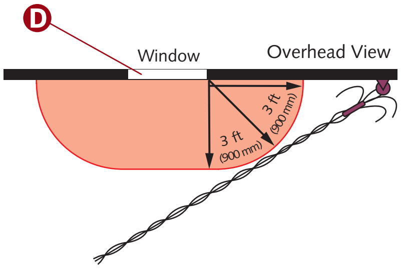
C The 3-ft (900-mm) clearance is not required for windows that are not designed to open.

D Except for the area above the window, the 3-ft (900-mm) clearance applies to the entire perimeter of windows, doors, etc.







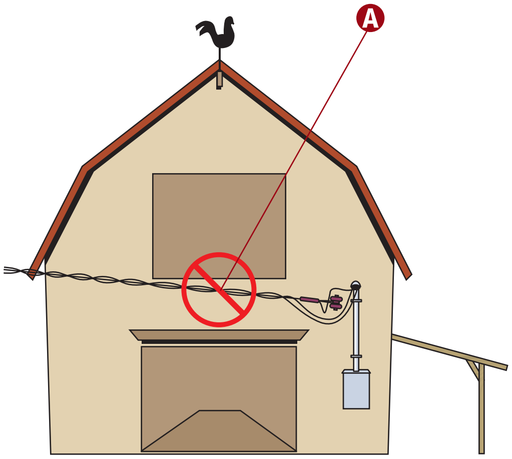


Conductors Obstructing Openings

A Overhead conductors must not obstruct building entrances to openings and must not be installed beneath openings designed for passage of materials, such as openings in farm and commercial buildings »*230.9(C)* and *225.19(D)(3)*«.

Note

A minimum 18-ft (5.5-m) vertical clearance is required over land routinely traversed by vehicles (such as cultivated, grazing, forest, and orchard) ***»230.24(B)(4)* and *225.18(4)*«**.



Conductors above Overhanging Portions of Roofs

A A maximum of 6 ft (1.8 m) of overhead service conductors pass over the roof.

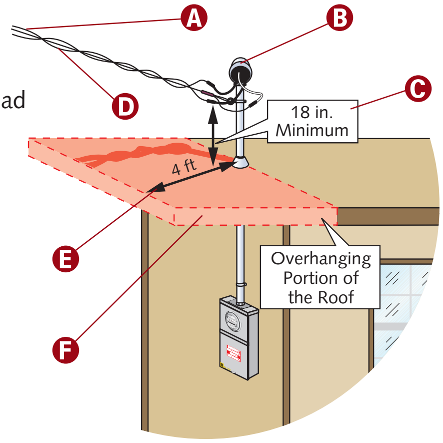
B Conductors terminate in a through-the-roof raceway (or other approved support).

C The vertical clearance for overhead service conductors can be reduced to 18 in. (450 mm) provided all 230.24(A) Exception No. 3 requirements are met.

D The voltage between conductors does not exceed 300 volts.

E The horizontal overhead service conductor measurement shall not exceed 4 ft (1.2 m).

F This reduction in clearance applies to conductors passing above roof overhang only.



Note

If all the requirements of 225.19(A) Exception No. 3 are met, the vertical clearance for the overhead spans of open conductors (outside feeders and branch circuit), including multiconductor cables, can be reduced to 18 in. (450 mm).

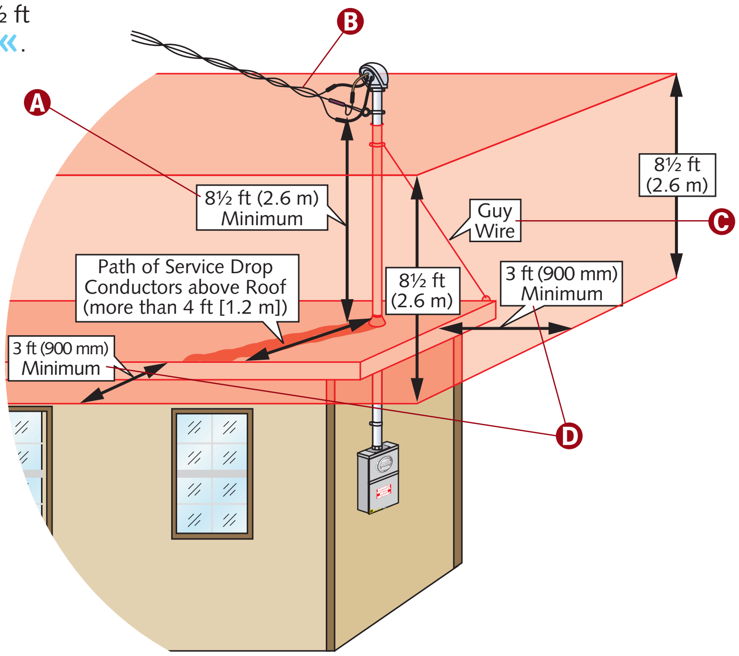
Conductor Clearance above Flat Roofs

A Conductors must have a vertical clearance of at least 8½ ft (2.6 m) above the roof surface »*230.24(A)* and *225.19(A)*«.

B Although overhead service conductors must not be readily accessible, they must comply with 230.24(A) through (E) for services not over 1000 volts, nominal »*230.24*«.

C The service mast shall be of adequate strength or be supported by braces or guys to withstand safely the strain imposed by the service-drop or overhead service conductors »*230.28(A)*«.

D The vertical clearance above roof level must be maintained for a distance of at least 3 ft (900 mm) from all edges of the roof »*230.24(A)* and *225.19(A)*«.



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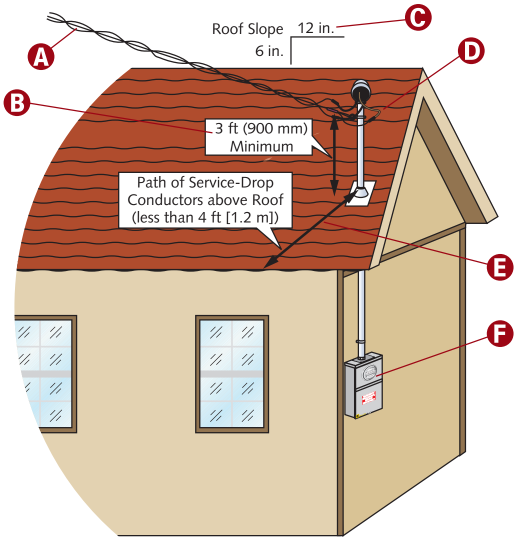
Conductors above Sloped Roofs



Ⓐ The voltage between the ungrounded (hot) conductors is 240 volts.

Ⓑ Where the voltage between conductors does not exceed 300, and the roof has a slope of not less than 4 in. in 12 in. (100 mm in 300 mm), a 3-ft (900-mm) clearance is permitted »*230.24(A) Exception No. 2* and *225.19(A) Exception No. 2*«.

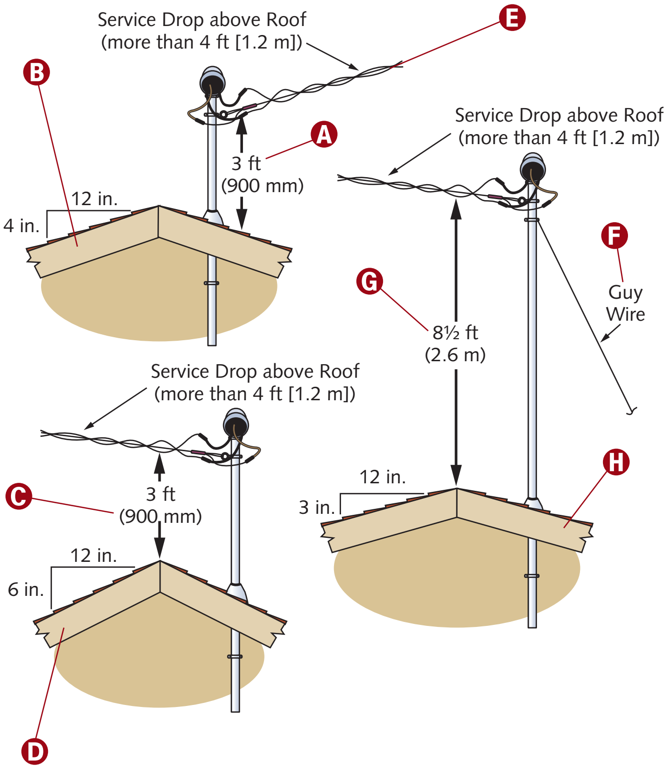
Ⓒ This roof, as denoted by this symbol, has a slope (or slant) of 6 in. in 12 in., which is greater than 4 in. in 12 in.

Ⓓ Unlike 230.24(B), which stipulates that "vertical clearance" also includes the drip loop, 230.24 provisions mention only the service-drop conductor. Because the end of the service-drop conductors could be part (or all) of the drip loop, caution is advised.

Ⓔ The horizontal service-drop measurement is less than 4 ft (1.2 m). However, the conductors pass over more than just the overhanging portion of this roof. Therefore, the clearance shall not be reduced to 18 in. (450 mm) »*230.24(A) Exception No. 3* and *225.19(A) Exception No. 3*«.

Ⓕ Service equipment rated at 1000 volts or less must be marked as suitable for use as service equipment. All service equipment shall be listed or field labeled. Individual meter socket enclosures are not considered service equipment but shall be listed and rated for the voltage and current rating of the service »*230.66*«. Meter sockets supplied by and under the exclusive control of an electric utility shall not be required to be listed »*230.66(B) Exception*«.

Various Roof Designs



Ⓐ Overhead service conductors above a roof with a slope of at least 4 in. in 12 in. (100 mm in 300 mm) have a minimum clearance of 3 ft (900 mm) »*230.24(A) Exception No. 2*«.

Ⓑ This roof has a slope of 4 in. in 12 in.

Ⓒ The point of attachment is usually the lowest point of the service drop. If, however, the conductors run above the roof's highest point (ridge or peak), a taller service mast may be required.

Ⓓ This roof has a slope of 6 in. in 12 in. (more than 4 in. in 12 in.).

Ⓔ The supply voltage for all three overhead service conductor illustrations is 240 volts.

Ⓕ A service mast supporting service-drop conductors must be of adequate strength or be supported by braces (or guys) to safely withstand the strain imposed by the service drop »*230.28(A)*«.

Ⓖ Overhead service conductors above a roof with a slope less than 4 in. in 12 in. (100 mm in 300 mm) shall have a minimum clearance of 8½ ft (2.6 m) »*230.24(A)*«.

Ⓗ This roof has a slope of 3 in. in 12 in. (less than 4 in. in 12 in.).

Note

Section 225.19 lists the vertical clearance for the overhead span of open conductors and open multiconductor cables used for outside feeders and branch circuits.

Because each of the illustrated service drops has a horizontal measurement of more than 4 ft (1.2 m), the amount of slope determines the minimum clearance requirement (either 3 ft [900 mm] or 8½ ft [2.6 m]).

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Clearance Reduction

A No more than 6 linear ft (1.8 m) of overhead service conductors pass over the roof.

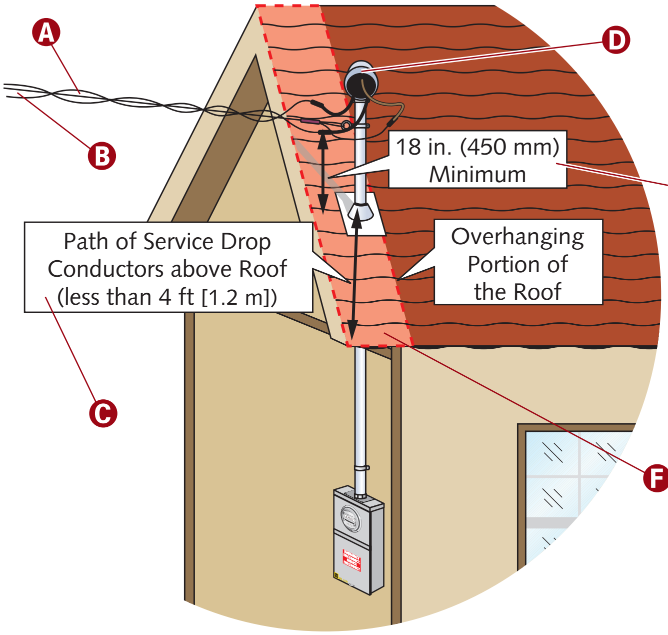
B Voltage between conductors does not exceed 300 volts.

C The horizontal overhead service conductor measurement does not exceed 4 ft (1.2 m).

D Conductors terminate in a through-the-roof raceway (or other approved support).

E The conductor's minimum vertical clearance is 18 in. (450 mm) where all 230.24(A) Exception No. 3 requirements have been met.

F The reduction in clearance (to 18 in. [450 mm]) applies to sloped roofs as well as flat roofs where the service drop passes above the overhang portion of the roof only.


A
D
B
18 in. (450 mm) Minimum
E
Path of Service Drop Conductors above Roof (less than 4 ft [1.2 m])
Overhanging Portion of the Roof
C
F

Note

If all the requirements of 225.19(A) Exception No. 3 are met, the vertical clearance for the overhead spans of open conductors (outside feeders and branch circuit), including multiconductor cables, can be reduced to 18 in. (450 mm).

Working Space around Equipment

Headroom and Height

A Overcurrent protective devices shall not be located in the vicinity of easily ignitible material (such as in clothes closets) »*240.24(D)*«. Although mentioned specifically, clothes closets are only one type of area that may contain easily ignitible materials.

B The minimum working space height for equipment operating at 1000 volts, nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized is 6½ ft (2.0 m) »*110.26(A)(3)*«. Service equipment and panelboards are examples of equipment likely to require examination, adjustment, servicing, or maintenance while energized.

C A clear workspace must extend from the grade, floor, or platform to the height of 6½ ft (2.0 m) or the height of the equipment, whichever is greater »*110.26(A)(3)*«.

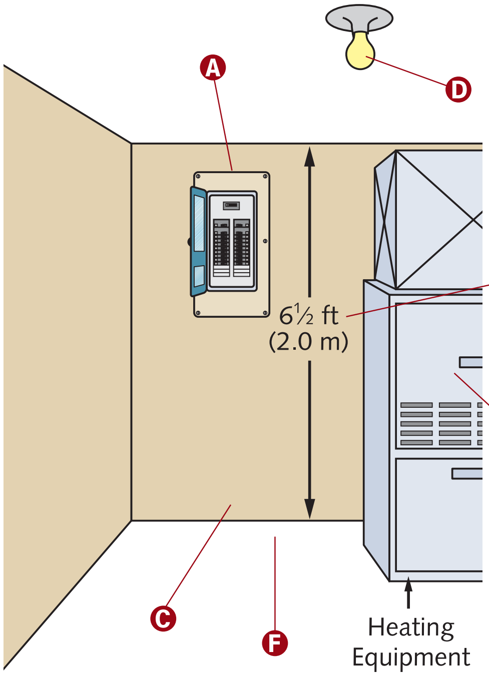
D Workspace illumination must be provided for all indoor installations of service equipment, panelboards, etc. Supplemental luminaires are not required where the workspace is illuminated by an adjacent light source »*110.26(D)*«.

E Access and working space must be provided and maintained around all electric equipment to permit ready and safe equipment operation and maintenance »*110.26*«.

F Working space required by 110.26 must not be used for storage »*110.26(B)*«.

Caution

Open equipment doors shall not impede access to or egress from the working space. Access or egress is impeded if one or more simultaneously opened equipment doors restrict working space access to less than 24 in. (610 mm) wide and 6½ ft (2.0 m) high »*110.26*«.



Note

Compliance with the minimum headroom of working space is optional for 200 amperes or less service equipment or panelboards in existing dwellings ***»110.26(A)(3) Exception No. 2«***.

Electric equipment workspace must have at least one entrance of sufficient area to provide access ***»110.26(C)(1)«***.

Caution

All illumination within the working space shall not be controlled by automatic means »*110.26(D)*«.

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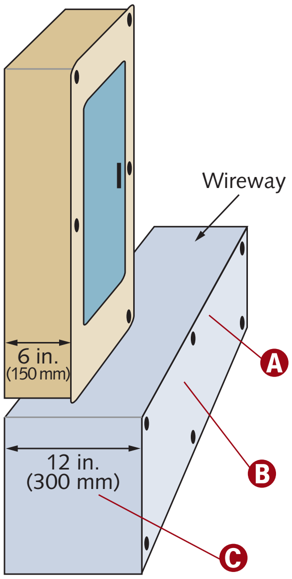
Maximum Depth of Associated Equipment

A Wireways are troughs (sheet metal or nonmetallic) with hinged or removable covers used to house and protect electric wires and cables. Conductors are laid in place after the raceway has been installed as a complete system »*Article 100*«.

B Article 376 outlines metal wireway provisions.

C In an electrical installation, other associated equipment or support structures, such as concrete pads, located above or below the electric equipment shall not extend more than 6 in. (150 mm) beyond the front of that electrical equipment »*110.26(A)(3)*«.



Caution

All service equipment, switchboards, switchgear, panelboards, and motor control centers shall be located in dedicated spaces and protected from damage »*110.26(E)*«. Surrounding space (equal to the width and depth of the equipment) must be clear of foreign systems. This dedicated equipment space extends from the floor to a height of 6 ft (1.8 m) above the equipment or to the structural ceiling, whichever is lower. A dropped, suspended, or similar ceiling that does not strengthen the building is not considered a structural ceiling. Sprinkler protection shall be permitted for the dedicated space, but the piping shall not be located in the dedicated equipment space. Other systems are permitted above the dedicated space provided protection is installed to avoid damage to the electrical equipment from leaks or breaks »*110.26(E)(1)(a)–(d)*«.

Note

Meters that are installed in meter sockets shall be permitted to extend beyond the other equipment. The meter socket must be installed in accordance with the provisions in 110.26 »***110.26(A)(3) Exception No. 3***«.

Working Space Width

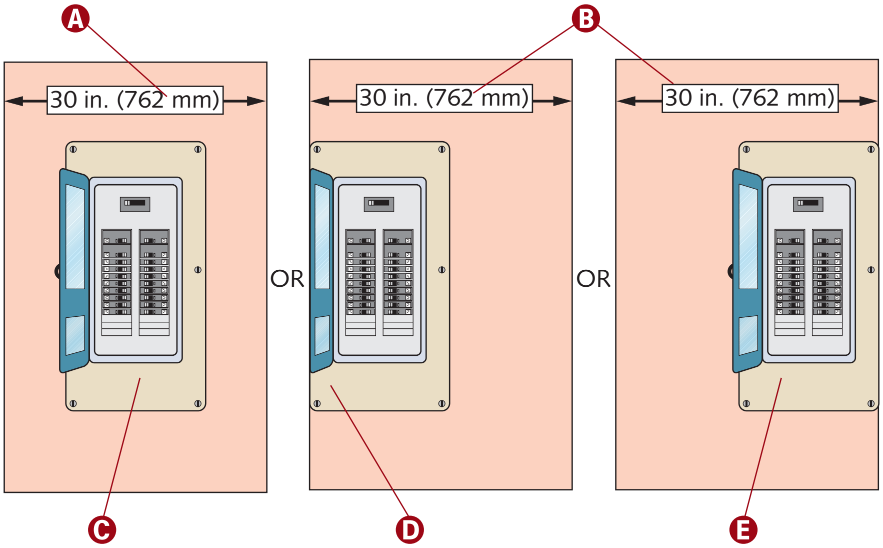
A The frontal workspace width of electric equipment must be the greater of the width of the equipment or 30 in. (762 mm) »*110.26(A)(2)*«.

B Section 110.26 does not stipulate that the panel (or equipment) be located in the center of the workspace. It can be located anywhere within the required space.

C A panel can be located in the middle, with equal amounts of space on each side, or . . .

D A panel can be located on the far left side, with the additional space on the right, or . . .

E A panel can be located on the far right, with the additional space on the left side.



Caution

The workspace extends to a height of 6½ ft (2.0 m) or the height of the equipment, whichever is greater. Dedicated equipment space that is equal to the height and depth of the equipment must also be provided from the floor to a height 6 ft (1.8 m) above the equipment or the structural ceiling, whichever is lower »*110.26(A)(3)* and *110.26(E)(1)(a)*«.

Note

The working space must always permit at least a 90° opening of equipment doors or hinged panels »***110.26(A)(2)***«.

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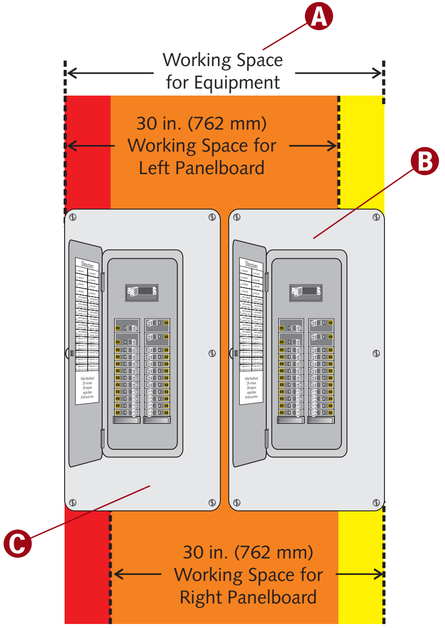
Overlapping Workspace

A The workspace width required in front of electric equipment is the greater of the width of the equipment or 30 in. (762 mm) » *110.26(A)(2)* «.

B In this configuration, it is not necessary that each panel have its own individual working space.

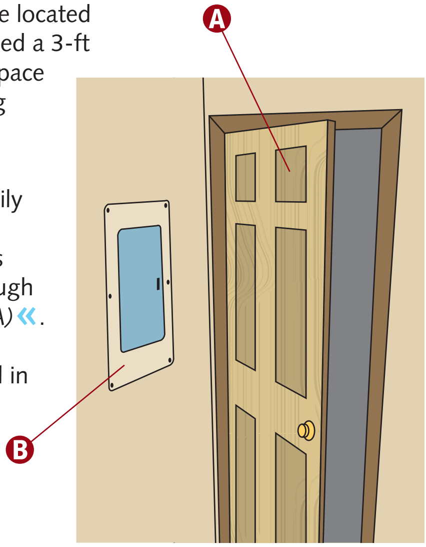
C A panel (or equipment) can share the working space of other equipment associated with the electrical installation.


A
Working Space for Equipment
30 in. (762 mm) Working Space for Left Panelboard
B
C
30 in. (762 mm) Working Space for Right Panelboard

Equipment behind Doors

A Equipment can be located behind a door provided a 3-ft (914-mm) working space is achieved by closing the door.

B Overcurrent devices must be readily accessible unless one of the conditions in 240.24(A)(1) through (4) apply » *240.24(A)* «. (The term "readily accessible" is defined in Unit 2 of this book.)



Working Space Depth

A Concrete, brick, or tile walls are recognized as grounded » *Table 110.26(A)(1) Note 2* «.

B Table 110.26(A)(1) specifies working space depth requirements in the direction of access to live parts. Distances are measured from the live parts (if exposed) or from the front or opening (if enclosed) » *110.26(A)(1)* «.

C The minimum workspace depth for equipment operating at 150 volts, nominal (or less) to ground, is 3 ft (900 mm), regardless of the conditions found in Table 110.26(A)(1). For equipment operating at 1000 volts, nominal, or less to ground, refer to Table 110.26(A)(1).

D Electric equipment must be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials are not acceptable » *110.13(A)* «.

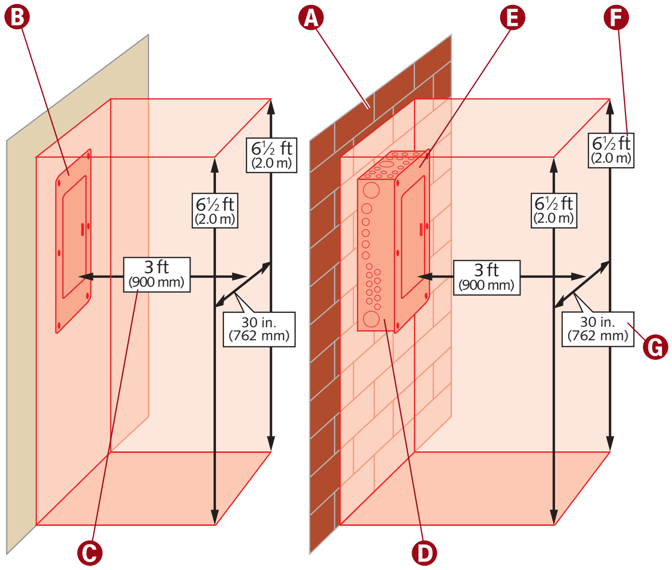
E Except as elsewhere required or permitted, the workspace area for equipment operating at 1000 volts, nominal (or less) to ground, which is likely to require examination, adjustment, servicing, or maintenance while energized, must comply with (1) through (4) of 110.26(A) » *110.26(A)* «.

Note

Installation and working space requirements for equipment operating over 1000 volts, nominal, are found in 110.30 through 110.34.

F The minimum working space height is 6½ ft (2.0 m), except for existing dwellings whose service equipment or panelboard does not exceed 200 amperes » *110.26(A)(3)* «.

G The minimum acceptable width of working space is 30 in. (762 mm) » *110.26(A)(2)* «.



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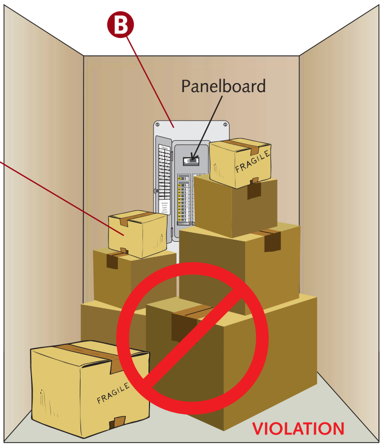
Working Space Not Used for Storage

A Access and working space shall be provided and maintained about all electrical equipment to permit ready and safe operation and maintenance of such equipment »*110.26*«.

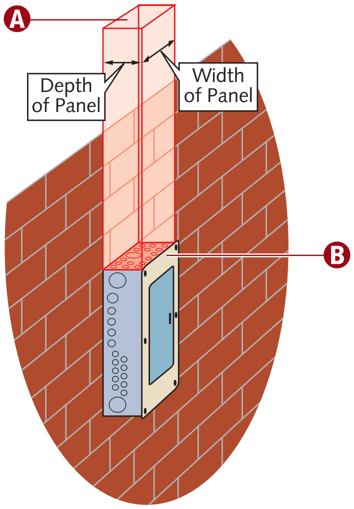
B Working space required by 110.26(A) shall not be used for storage »*110.26(B)*«.



Indoor Dedicated Equipment Space

A The space equal to the width and depth of the equipment and extending from the floor to a height of 6 ft (1.8 m) above the equipment or to the structural ceiling, whichever is lower, must be dedicated to the electrical system. A dropped, suspended, or similar ceiling that does not strengthen the building is not considered a structural ceiling »*110.26(E)(1)(a)* and *(d)*«.

B All switchboards, switchgear, panelboards, and motor control centers must be located in dedicated spaces and must be protected from damage »*110.26(E)*«.



Note

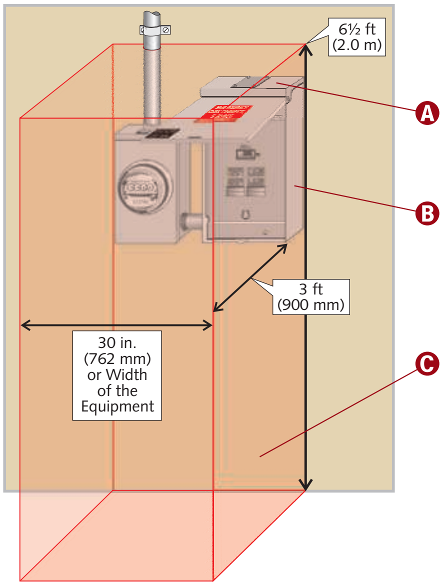
No piping, ducts, leak protection apparatus, or other equipment foreign to the electrical installation shall be located in this dedicated equipment space ***»110.26(E)(1)(a)«***.

Outdoor Service Equipment

A The space equal to the width and depth of the equipment, and extending from grade to a height of 6 ft (1.8 m) above the equipment, shall be dedicated to the electrical installation. No piping or other equipment foreign to the electrical installation shall be located in this zone »*110.26(E)(2)(c)*«.

B Panelboards shall be mounted in cabinets, cutout boxes, or identified enclosures and shall be dead front »*408.38*«. "Dead front" means having no exposed live parts on the operating side of the equipment »*Article 100*«.

C Outdoor electrical equipment shall be installed in identified enclosures, protected from accidental contact by unauthorized personnel or by vehicular traffic, and protected from accidental spillage or leakage from piping systems. The zone described in 110.26(A) must be included in the minimum clear working space. No architectural appurtenance or other equipment can occupy space in this zone »*110.26(E)(2)(a) and (b)*«. Structural overhangs or roof extensions shall be permitted in this zone »*110.26(E)(2)(c) Exception*«.



Note

Panelboards in damp or wet locations must comply with 312.2 ***»408.37«***. In damp or wet locations, surface-type enclosures must be installed so moisture or water will not enter or accumulate within the enclosure. Unless the enclosure is nonmetallic, it must be mounted so there is at least ¼-in. (6-mm) airspace between the enclosure and the wall or other supporting surface. Enclosures installed in wet locations shall be weatherproof. For enclosures in wet locations, raceways or cables entering above the level of uninsulated live parts shall use fittings listed for wet locations ***»312.2«***.

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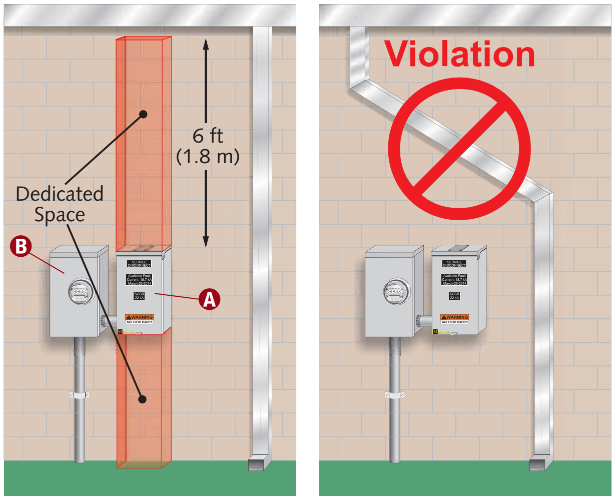
Outdoor Dedicated Equipment Space

Dedicated equipment space pertains to all switchboards, switchgear, panelboards, and motor control centers »*110.26(E)*«. Outdoor installations shall comply with 110.26(E)(2)(a) through (c) »*110.26(E)(2)*«.

A The space equal to the width and depth of the equipment, and extending from grade to a height of 6 ft (1.8 m) above the equipment, shall be dedicated to the electrical installation. No piping or other equipment foreign to the electrical installation shall be located in this zone »*110.26(E)(2)(c)*«.

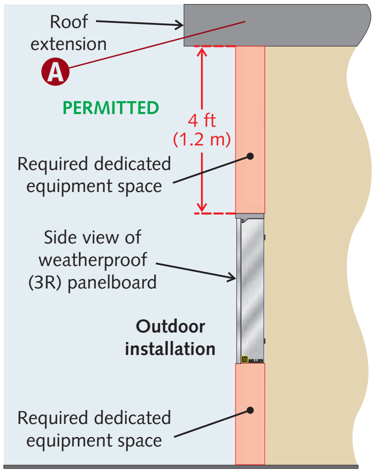
B While it is a good idea to have dedicated space for meter bases (meter socket enclosures), it is not required. Dedicated space is only required for switchboards, switchgear, panelboards, and motor control centers.



Roof Extensions

The space equal to the width and depth of the equipment, and extending from grade to a height of 6 ft (1.8 m) above the equipment, shall be dedicated to the electrical installation. No piping or other equipment foreign to the electrical installation shall be located in this zone.

A Structural overhangs and roof extensions are permitted in dedicated equipment space »*110.26(E)(2)(c) Exception*«.


Roof extension
A
PERMITTED
4 ft
(1.2 m)
Required dedicated equipment space
Side view of weatherproof (3R) panelboard
Outdoor installation
Required dedicated equipment space

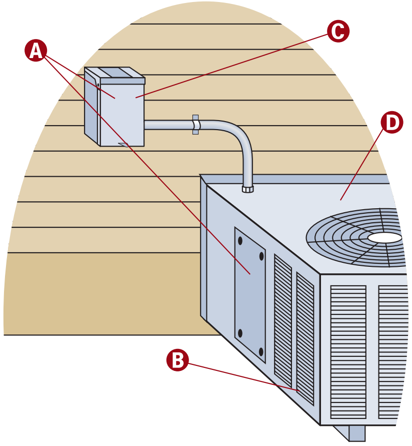
Electrical Equipment

A All electric equipment must be surrounded by sufficient unobstructed space to allow ready and safe equipment operation and maintenance »*110.26*«. Working space is mandatory for equipment likely to require examination, adjustment, servicing, or maintenance while energized »*110.26(A)*«.

B Article 440 details air-conditioning and refrigerating equipment provisions. General requirements, disconnecting means, overcurrent protection, conductor sizing, and room air conditioners are a few of the covered topics.

C The disconnecting means for air-conditioning or refrigerating equipment must be located within sight from the equipment and must also be readily accessible »*440.14*«.

D Installation of the disconnecting means can be on, or within, the air-conditioning or refrigerating equipment »*440.14*«. If installed within the equipment, it must be readily accessible. ("Accessible, Readily" is defined in Article 100 of the *NEC* and Unit 2 of this book.)



Note

The disconnecting means for air-conditioning and refrigerating equipment must meet the clear working space requirements found in 110.26(A) ***»440.14«***.

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Service Equipment and Panelboards

Emergency Disconnects

For one- and two-family dwelling units, all service conductors shall terminate in disconnecting means having a short-circuit current rating equal to or greater than the available fault current, installed in a readily accessible outdoor location. If more than one disconnect is provided, they shall be grouped. Each disconnect shall be marked in accordance with 230.85 and the markings shall comply with 110.21(B) »*230.85*«.

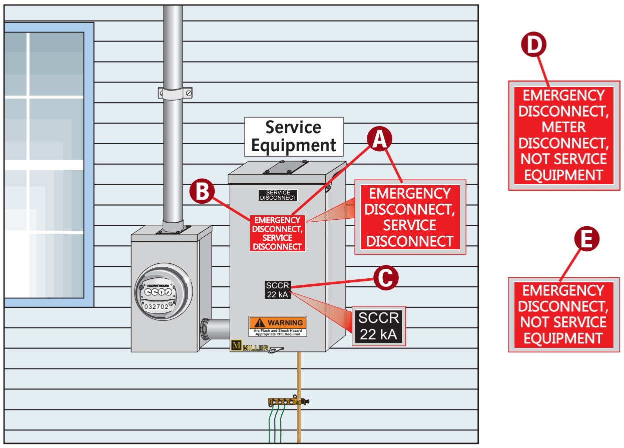
Ⓐ This is a service disconnect so this disconnect shall be marked: EMERGENCY DISCONNECT, SERVICE DISCONNECT.

Ⓑ As required by 230.85, this plaque complies with 110.21(B). This marking warns of the hazards using effective words and colors. The marking is permanently affixed to the equipment and is not be handwritten. The plaque is of sufficient durability to withstand the environment involved.

Ⓒ This disconnecting means has a short-circuit current rating greater than the available fault current.

Ⓓ Meter disconnects installed per 230.82(3) shall be marked: EMERGENCY DISCONNECT, METER DISCONNECT, NOT SERVICE EQUIPMENT.

Ⓔ Other listed disconnect switches or circuit breakers on the supply side of each service disconnect that are suitable for use as service equipment shall be marked: EMERGENCY DISCONNECT, NOT SERVICE EQUIPMENT.


Service Equipment
A
B
C
D
E
EMERGENCY DISCONNECT, SERVICE DISCONNECT
SCCR 22 kA
EMERGENCY DISCONNECT, METER DISCONNECT, NOT SERVICE EQUIPMENT
EMERGENCY DISCONNECT, NOT SERVICE EQUIPMENT
SERVICE DISCONNECT
WARNING
MILLER

Caution

Where service equipment is replaced, all of the requirements of 230.85 shall apply. Where only meter sockets, service entrance conductors, or related raceways and fittings are replaced, the requirements of 230.85 shall not apply »*230.85(C)* and *Exception*«.

Note

Markings for the required emergency disconnect shall (1) be located on the outside front of the disconnect enclosure with red background and white text and (2) have letters that are at least ½ in. high »*230.85(E)(2)*«.

Panelboards

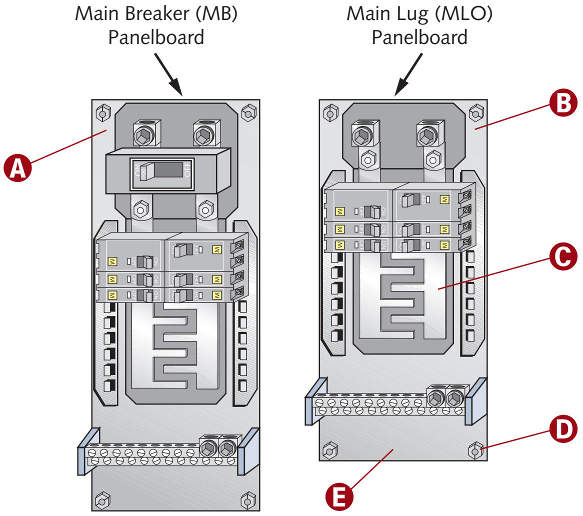
Ⓐ A panelboard (1) consists of one or more panel units designed for assembly, thereby forming a single panel; (2) includes buses and automatic overcurrent devices; (3) may contain switches for controlling circuits (light, heat, or power); (4) is designed for mounting in a cabinet or cutout box; (5) is designed for placement in or against a wall, partition, or other support; and (6) is accessible only from the front »*Article 100*«. (Panelboards include, but are not limited to, circuit breaker panels and fused or nonfused switches [disconnects].)

Ⓑ Panelboards include overcurrent devices.

Ⓒ Panelboards include buses.

Ⓓ Panelboards are mounted in cabinets or cutout boxes that are accessible only from the front. Panelboard requirements are in Article 408. Article 312 covers the installation and construction specifications of cabinets.

Ⓔ Panelboards can be single units or multipanel units.



Enclosures

Ⓐ A cabinet is an enclosure that by design may be surface or flush mounted, having a frame, mat, or trim attached to which are (or can be) swinging door(s) »*Article 100*«.

Ⓑ Cabinets can be either flush or surface mounted.

Ⓒ Cutout boxes have swinging doors or covers attached directly to the enclosure.

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D Cabinets include trims with swinging doors.

E **Type 1** enclosures, intended for indoor use, primarily provide protection against contact with the enclosed equipment in locations not subject to unusual service conditions.

F Another type of enclosure, a cutout box, is designed for surface mounting and has swinging doors (or covers) secured directly to and extending from one of the enclosure walls »*Article 100*«.

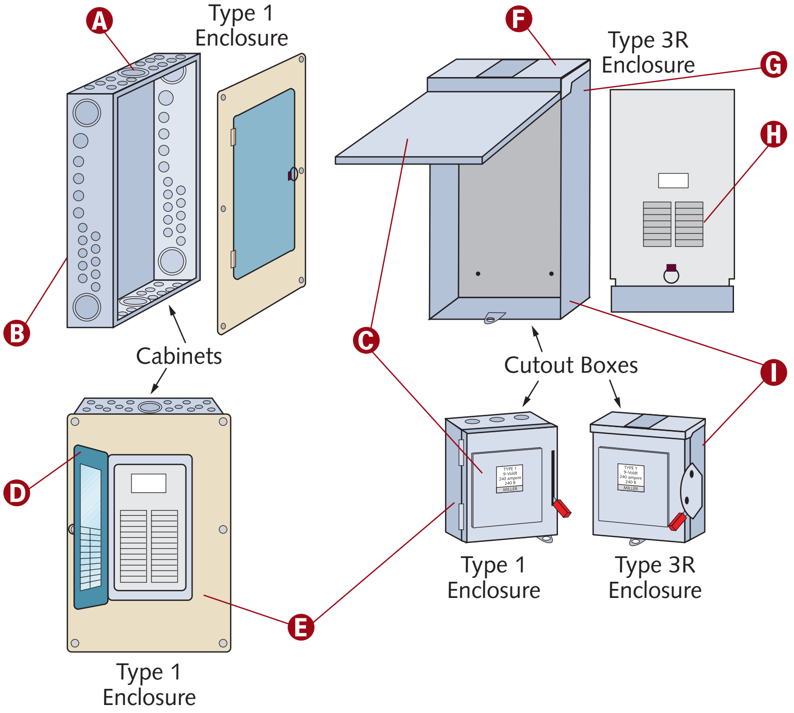
G Cutout boxes are surface mounted.

H "Dead front" is defined as having no exposed live parts on the operating side of the equipment »*Article 100*«.

I **Type 3R** enclosures, intended for outdoor use, primarily provide protection against falling precipitation and must remain undamaged by external formation of ice. They are not intended to provide protection against conditions such as dust, internal condensation, or internal icing.

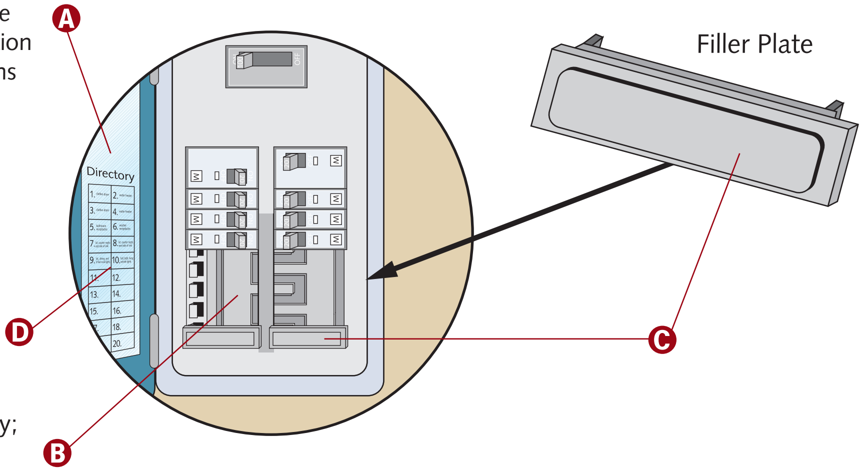
Note

Enclosure types are listed in Table 110.28.



Unused Openings and Circuit Directory

A Every circuit and circuit modification shall be provided with a legible and permanent description that complies with all of the following conditions as applicable: (1) located at each switch or circuit breaker in a switchboard or switchgear; (2) included in a circuit directory that is located on the face of, inside of, or in an approved location adjacent to the panel door in the case of a panelboard; (3) clear, evident, and specific to the purpose or use of each circuit, including spare positions with an unused overcurrent device; (4) described with a degree of detail and clarity that is unlikely to result in confusion between circuits; (5) not dependent on transient conditions of occupancy; and (6) clear in explaining abbreviations and symbols when used »*408.4(A)*«.



B Busbars, both insulated and bare, must be rigidly mounted »*408.51*«.

C Unused openings, other than those intended for the operation of equipment, those intended for mounting purposes, or those permitted as part of the design for listed equipment, shall be closed to afford protection substantially equivalent to the wall of the equipment »*110.12(A)*«.

D Each disconnecting means shall be legibly marked to indicate its purpose unless located and arranged so the purpose is evident. The marking must be durable enough to withstand the surrounding environment »*110.22(A)*«.

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Circuit Breakers

The standard ampere ratings for fuses and inverse-time circuit breakers are 10, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000 amperes. Fuses and inverse-time circuit breakers with nonstandard ampere ratings can be used. Additional standard ampere ratings for fuses are 1, 3, 6, 10, and 601 »*240.6(A)*«.

Ⓐ A **circuit breaker** is a device designed to both open and close a circuit by nonautomatic means and to open the circuit automatically when subjected to a predetermined overcurrent without being damaged (when properly applied within its rating) »*Article 100*«.

Ⓑ All circuit breakers having an interrupting rating other than 5000 amperes must be appropriately marked. The interrupting rating is not required on circuit breakers used for supplementary protection »*240.83(C)*«. (Note: The ampere interrupting rating [AIR] is not the current rating of the circuit breaker.)

Ⓒ Circuit breakers must have a voltage rating (clearly marked) no less than the nominal system voltage that indicates their ability to interrupt fault current (between phases or phase to ground) »*240.83(E)*«.

Ⓓ General-use and motor-circuit switches, circuit breakers, and molded case switches, where mounted in an enclosure as described in 404.3, shall clearly indicate whether they are in the open (off) or closed (on) position »*404.7*«.

Ⓔ For vertically operated circuit breakers, the up position of the handle shall be the closed (on) position »*240.81* and *404.7*«.

Ⓕ A circuit breaker's ampere rating must be durably marked and remain visible after installation. When necessary to ensure visibility, removal of a trim or cover is permitted »*240.83(A)*«.

Ⓖ The term **inverse time** is a qualifying term indicating an intentional delay in the tripping action of a circuit breaker. The length of the delay decreases as the magnitude of the current increases »*Article 100*«.

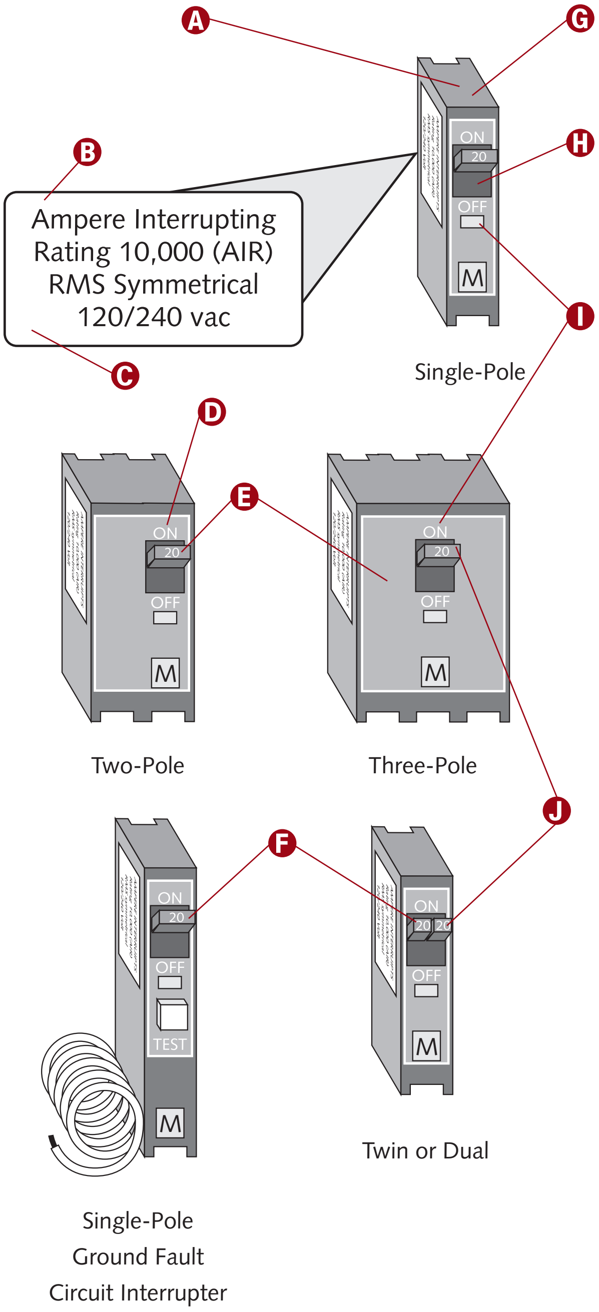
Ⓗ A **nonadjustable** circuit breaker does not allow the value of current that triggers the tripping action, or the time required for its operation, to be altered »*Article 100*«.

Ⓘ A circuit breaker's open (off) or closed (on) positions must be clearly identified »*240.81* and *404.7*«.

Ⓙ The ampere rating of any circuit breaker rated at 100 amperes or less, and 1000 volts or less, must be molded, stamped, etched, or similarly marked into the handle or escutcheon area »*240.83(B)*«.

Caution

Circuit breakers and fuses can be connected in parallel provided they are factory assembled and listed as a unit. Individual fuses, circuit breakers, or combinations shall not otherwise be connected in parallel »*240.8*«.



Note

Circuit breakers must be trip free as well as manually operable in both the closed and opened positions. Although a circuit breaker may normally operate by electrical or pneumatic means, a means of manual operation must also be provided »*240.80*«.

Circuit breakers used as switches in 120-volt and 277-volt fluorescent lighting circuits must be listed and be marked "SWD" or "HID" »*240.83(D)*«.

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Arc-Fault Circuit Interrupter (AFCI)

Ⓐ An AFCI is a device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected »*Article 100*«.

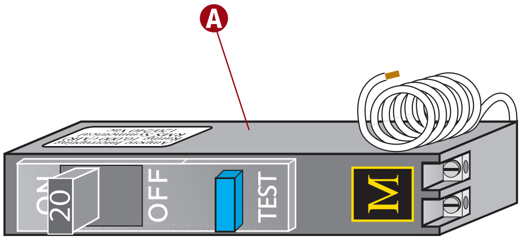
Warning

All 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar rooms or areas shall be protected by any of the means described in 210.12(A)(1) through (6) »*210.12(B)*«. See 210.12(A)(1) through (6) for the complete list of permitted types of AFCI protection.

Note

All 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets and devices installed in dormitory unit bedrooms, living rooms, hallways, closets, bathrooms, and similar rooms shall be protected by any of the means described in 210.12(A)(1) through (6) ***»210.12(C)«***.

All 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets and devices installed in guest rooms and guest suites of hotels and motels; patient sleeping rooms in nursing homes; limited-care facilities; and areas designed exclusively as sleeping quarters in fire stations, police stations, ambulance stations, rescue stations, ranger stations, and similar locations shall be protected by any of the means described in 210.12(A)(1) through (6) ***»210.12(D)«***.



Arc-Fault Circuit Interrupter (AFCI)

Note

In any of the areas specified in 210.12(B), (C), or (D), where branch-circuit wiring is modified, replaced, or extended, the branch circuit shall be protected by one of the following: (1) any of the means described in 210.12(A)(1) through (A)(6); or (2) a listed outlet branch circuit–type AFCI located at the first receptacle outlet of the existing branch circuit ***»210.12(E)«***.

Note

A back-fed device functioning as a service disconnect must be permanently marked to identify it as a service disconnect ***»230.70(B)«***.

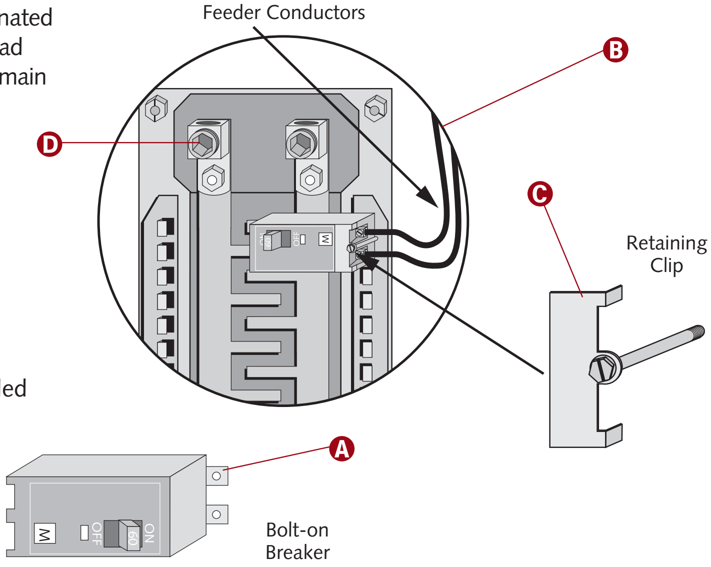
Back-Fed Devices

Ⓐ Since a bolt-on breaker is not a plug-in-type overcurrent protection device, no additional fastener (screw, clip, etc.) is needed.

Ⓑ These remote panelboard (subpanel) feeder conductors originated from a main panelboard. The conductors are connected to the load side terminals of the circuit breaker, instead of connecting to the main lugs. In this configuration (the reverse of normal operation), the conductor feeds the breaker, thus the term "back-fed device."

Ⓒ Back-fed plug-in-type overcurrent protection devices or plug-in-type main lug assemblies used to terminate field-installed ungrounded supply conductors must be secured to the panelboard by an additional fastener mounting means that requires other than a pull to release the device from the mounting means on the panel »*408.36(D)*«.

Ⓓ Tightening torque values for terminal connections shall be as indicated on equipment or in installation instructions provided by the manufacturer. An approved means shall be used to achieve the indicated torque value »*110.14(D)*«.



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Installation

A Enclosures installed in wet locations must be weatherproof »*312.2*«.

B Cabinets and cutout boxes must have approved space to prevent crowding of installed conductors »*312.7*«.

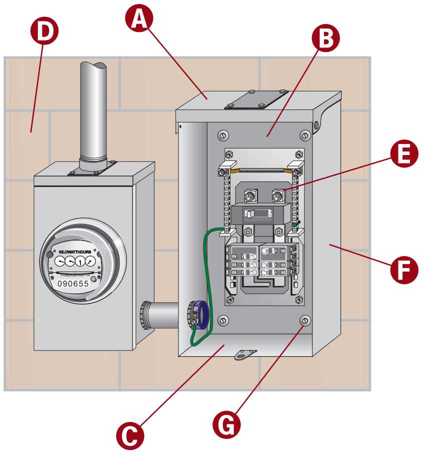
C Panelboards in damp or wet locations must be installed in compliance with 312.2 »*408.37*«.

D Concrete, brick, and tile walls are considered to be grounded »*Table 110.26(A)(1) Condition 2*«.

E The service conductors must be attached to the service disconnecting means by pressure connectors, clamps, or other approved means »*230.81*«.

F In damp or wet locations, surface-type enclosures (within the scope of Article 312) must be located or equipped so that moisture or water does not enter or accumulate within the cabinet or cutout box. A minimum of ¼-in. (6-mm) airspace between the enclosure and the wall or other supporting surface is required »*312.2*«.

G Electric equipment must be firmly secured to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials are not acceptable »*110.13(A)*«.



Note

For enclosures in wet locations, raceways or cables entering above uninsulated live parts shall use fittings listed for wet locations »***312.2***«.

Caution

All services supplying dwelling units shall be provided with a surge-protective device (SPD). The SPD shall be an integral part of the service equipment or shall be located immediately adjacent thereto unless it is located at each next level distribution equipment downstream toward the load. The SPD shall be a Type 1 or Type 2 SPD. When replacing service equipment, all requirements 230.67 shall be met »*230.67(A) through (D)*«.

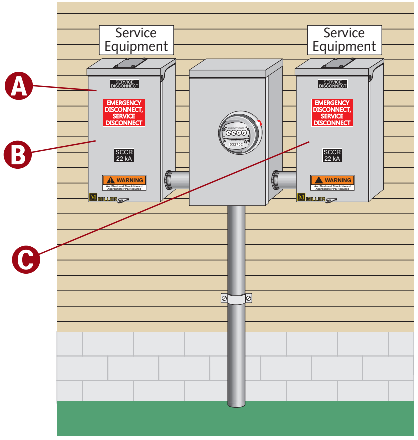
Grouping of Service Disconnects

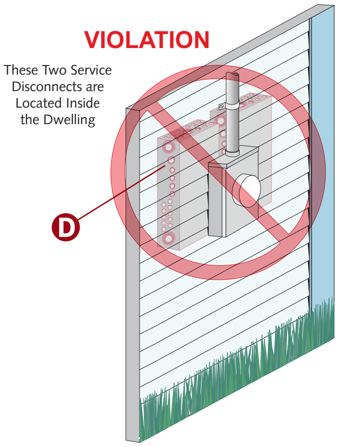
A Energized parts of service equipment must be enclosed as specified in 230.62(A) or guarded as specified in 230.62(B) »*230.62*«.

B Two to six circuit breakers or sets of fuses are acceptable as the overcurrent device to provide overload protection. The sum of the ratings of the circuit breakers or fuses shall be permitted to exceed the ampacity of the service conductors, provided the calculated load does not exceed the ampacity of the service conductors »*230.90(A) Exception No. 3*«.

C A service disconnecting means consisting of more than one switch or circuit breaker, as permitted by 230.71, must have a combined rating of all switches or circuit breakers used, not less than the rating required by 230.79 »*230.80*«.

D Although these service disconnects are grouped, they are not permitted inside the dwelling unit. The service disconnects shall be installed in a readily accessible outdoor location unless emergency disconnect(s) are provided in a readily accessible outdoor location in compliance with 230.85.




VIOLATION
These Two Service Disconnects are Located Inside the Dwelling
D

Caution

For one- and two-family dwelling units, the service disconnecting means or emergency meter disconnect(s) must be located in a readily accessible outdoor location »*230.85*«.

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Service Equipment

A Because individual meter socket enclosures are not considered service equipment, a "suitable for use as service equipment" marking is not required. Individual meter socket enclosures shall be listed and rated for the voltage and current rating of the service unless the meter sockets are supplied by and under the exclusive control of an electric utility »*230.66* and *Exception*«.

B Service equipment rated 1000 volts or less shall be marked to identify it as being suitable for use as service equipment. All service equipment shall be listed or field labeled »*230.66(A)*«.

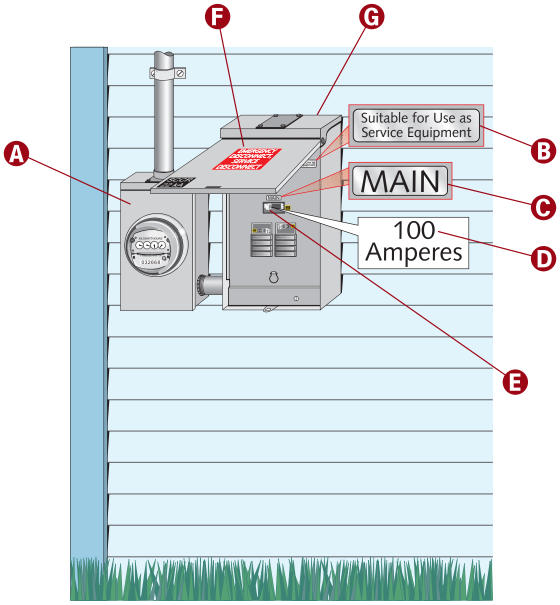
C Each service disconnect must be permanently marked, identifying it as a service disconnect »*230.70(B)*«.

D A one-family dwelling service disconnecting means must have a minimum rating of 100 amperes, 3-wire »*230.79(C)*«.

E A means to disconnect all ungrounded conductors in a building (or other structure) from the service conductors must be provided »*230.70*«.

F To comply with 230.85, this service disconnect is marked: EMERGENCY DISCONNECT, SERVICE DISCONNECT.

G For one- and two-family dwelling units, the service disconnecting means or emergency meter disconnect(s) must be located outdoors in a readily accessible location »*230.85*«.


F
G
A
Suitable for Use as Service Equipment
B
MAIN
C
100 Amperes
D
E
EMERGENCY DISCONNECT SERVICE DISCONNECT

Warning

Local utility companies often set parameters (height, grounding, etc.) for metering equipment installation. Local jurisdictions may also have special regulations concerning service equipment. Obtain copies of all applicable provisions for the area in which the equipment will be installed.

Note

Maximum service conductor lengths are not specified within a building or structure. The provision merely states that the disconnecting means must be located nearest the point of service conductor entrance. Since the length of service conductors can alter available short-circuit current, the length should be kept to a minimum. Some local jurisdictions define a maximum acceptable length for service conductors.

Caution

Neither service disconnecting means nor overcurrent protective devices (other than supplementary overcurrent protection) can be located in bathrooms »*230.70(A)(2)* and *240.24(E)*«.

Caution

All services supplying dwelling units shall be provided with a surge-protective device (SPD). The SPD shall be an integral part of the service equipment or shall be located immediately adjacent thereto unless it is located at each next level distribution equipment downstream toward the load. The SPD shall be a Type 1 or Type 2 SPD. When replacing service equipment, all requirements 230.67 shall be met. SPDs shall have a nominal discharge current rating (In) of not less than 10kA »*230.67(A)* through *(E)*«.

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Multiple Service Disconnects

A Section 230.90 requires that each ungrounded (hot) service conductor have overload protection. Such protection shall be provided by an overcurrent device in series with each ungrounded service conductor having a rating (or setting) not higher than the allowable conductor ampacity »*230.90(A)*«. Under 230.90(A), five exceptions allow more than one overcurrent device for overload protection.

B Two to six circuit breakers or sets of fuses can serve as the overcurrent device providing overload protection »*230.90(A) Exception No. 3*«.

C The total circuit breaker (or fuse) ratings can exceed the service conductors ampacity, provided the calculated load (in accordance with Article 220) does not exceed the ampacity of the service conductors »*230.90(A) Exception No. 3*«.

D The service disconnecting means shall have a rating not less than the calculated load to be carried, determined in accordance with Parts III, IV, or V of Article 220, as applicable. In no case shall the rating be lower than specified in 230.79(A), (B), (C), or (D) »*230.79*«.

E Each service disconnect must be permanently marked as a service disconnect »*230.70(B)*«. Each individual service disconnect must be marked. A single marking for multiple service disconnects is not permitted.

F Two to six service disconnecting means shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of types of equipment specified in 230.71(B)(1) through (6) »*230.71(B)*«. This installation complies with 230.71(B) because there are not more than six separate enclosures with a main service disconnecting means in each enclosure.

G To comply with 230.85, each of the service disconnects are marked: EMERGENCY DISCONNECT, SERVICE DISCONNECT.

Note

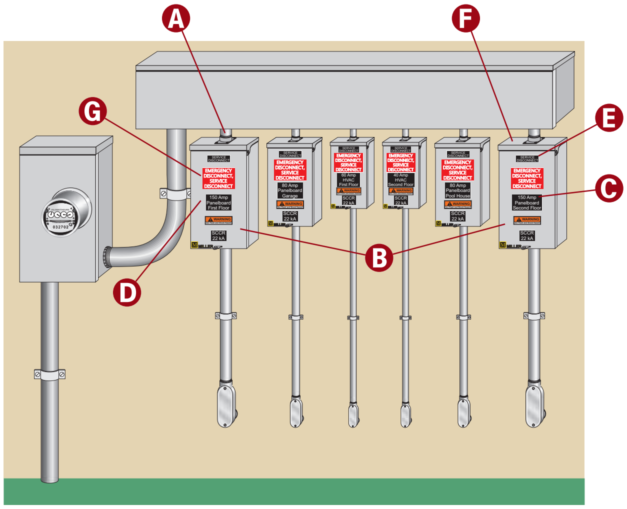
For one- and two-family dwelling units, the service disconnecting means or emergency meter disconnect(s) must be located outdoors in a readily accessible location »***230.85***«.

Caution

The service disconnecting means shall not consist of two to six switches or sets of circuit breakers, or a combination of two to six switches and sets of circuit breakers, mounted in a single enclosure.

Note

A set of fuses shall be considered all the fuses required to protect all of a circuit's ungrounded conductors »***230.90(A)***«.


A
F
G
E
C
B
D
SERVICE DISCONNECT
EMERGENCY DISCONNECT, SERVICE DISCONNECT
150 Amp Panelboard First Floor
80 Amp Panelboard Garage
60 Amp HVAC First Floor
40 Amp HVAC Second Floor
80 Amp Panelboard Pool House
150 Amp Panelboard Second Floor
WARNING
SCCR 22 kA
MILLER

Existing Panelboards

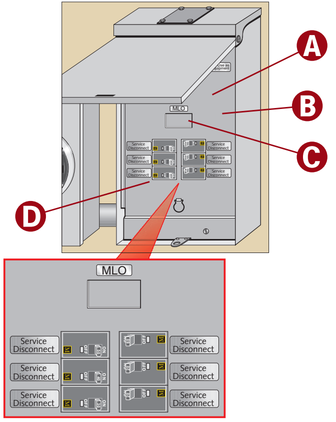
Ⓐ All panelboards shall have a rating not less than the minimum feeder capacity required for the load calculated in accordance with Part III, IV, or V of Article 220, as applicable »*408.30*«.

Ⓑ In addition to the requirement of 408.30, a panelboard shall be protected by an overcurrent protective device having a rating not greater than that of the panelboard unless meeting one of the exceptions in 408.36.

Ⓒ For existing panelboards, individual protection shall not be required for a panelboard used as service equipment for an individual residential occupancy »*408.36 Exception No. 2*«.

Ⓓ Prior to the 2020 edition of the National Electrical Code, the service disconnecting means was permitted to consist of not more than six switches or sets of circuit breakers, or a combination of not more than six switches and sets of circuit breakers, mounted in a single enclosure. This type of installation is no longer permitted.

Existing Panelboard



Caution

When replacing service equipment, all of the requirements in 230.67 shall be met »*230.67(D)*«. Requirements in 230.67 pertain to surge-protective devices (SPDs).

Panelboards

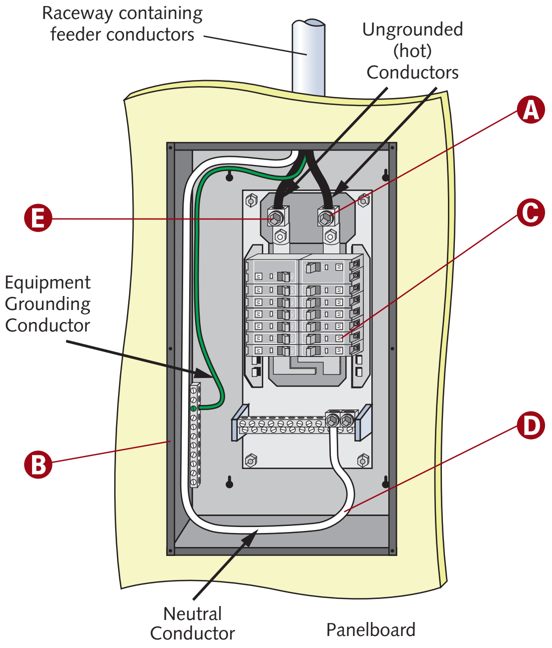
Ⓐ In addition to the requirement of 408.30, a panelboard shall be protected by an overcurrent protective device having a rating not greater than that of the panelboard. This overcurrent protective device shall be located within or at any point on the supply side of the panelboard »*408.36*«.

Ⓑ The front edge of cabinets (panelboards) situated in walls constructed of noncombustible material (drywall, concrete, tile, etc.) must be within ¼ in. (6 mm) of the finished surface »*312.3*«.

Ⓒ Panelboards equipped with snap switches rated at 30 amperes or less shall have overcurrent protection of 200 amperes or less »*408.36(A)*«.

Ⓓ A grounded conductor shall not be connected to normally non-current-carrying metal parts of equipment, to equipment grounding conductor(s), or be reconnected to ground on the load side of the service disconnecting means except as otherwise permitted in Article 250 »*250.24(B)*«.

Ⓔ Tightening torque values for terminal connections shall be as indicated on equipment or in installation instructions provided by the manufacturer. An approved means shall be used to achieve the indicated torque value »*110.14(D)*«.


Raceway containing feeder conductors
Ungrounded (hot) Conductors
A
E
C
Equipment Grounding Conductor
B
D
Neutral Conductor
Panelboard

Note

Individual protection shall not be required for a panelboard protected side by two main circuit breakers or two sets of fuses, in other than service equipment, having a combined rating not greater than that of the panelboard. A panelboard constructed or wired under this exception shall not contain more than 42 overcurrent devices. For the purposes of determining the maximum of 42 overcurrent devices, a 2-pole or a 3-pole circuit breaker shall be considered as two or three overcurrent devices, respectively »***408.36 Exception No. 1***«.

Note

A panelboard shall be provided with physical means to prevent the installation of more overcurrent devices than that for which the panelboard was designed, rated, and listed »***408.54***«.

Caution

Cabinets in walls constructed of combustible material (wood, etc.) must be flush with or extend beyond the finished surface »*312.3*«.

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Common-Trip and Single-Pole Circuit Breakers

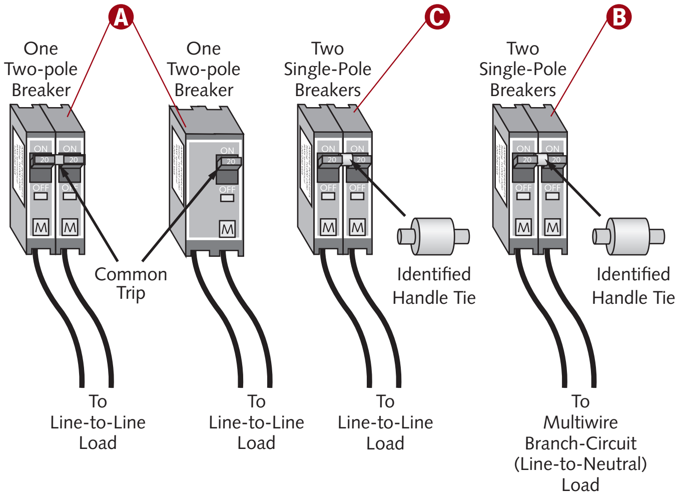
A Circuit breakers must open all ungrounded conductors of the circuit both manually and automatic unless permitted in 240.15(B)(1) through (4) »*240.15(B)*«.

B Individual single-pole circuit breakers, with identified handle ties, are permitted as protection for each ungrounded conductor of multiwire branch circuits serving only single-phase, line-to-neutral loads »*240.15(B)(1)*«. In accordance with 210.4(B), each multiwire branch circuit must be provided with a means that will simultaneously disconnect all ungrounded (hot) conductors at the point where the branch circuit originates. There are no exceptions to this rule.

Note

For line-to-line loads in 4-wire, 3-phase systems or 5-wire, 2-phase systems, individual single-pole circuit breakers rated 120/240 volts ac with identified handle ties shall be permitted as the protection for each ungrounded conductor, if the systems have a grounded neutral point and the voltage to ground, does not exceed 120 volts »***240.15(B)(3)***«.

C In grounded systems, individual single-pole circuit breakers, rated 120/240 volts alternating current (ac), with identified handle ties are permitted as protection for each ungrounded conductor for line-to-line connected loads for single-phase circuits »*240.15(B)(2)*«.


A
C
B
One Two-pole Breaker
One Two-pole Breaker
Two Single-Pole Breakers
Two Single-Pole Breakers
Common Trip
Identified Handle Tie
Identified Handle Tie
To Line-to-Line Load
To Line-to-Line Load
To Line-to-Line Load
To Multiwire Branch-Circuit (Line-to-Neutral) Load

Cartridge Fuses and Fuseholders

Cartridge fuses and fuseholders are classified according to voltage and amperage ranges. Fuses rated 1000 volts, nominal, or less can be used for voltages at or below their ratings »*240.61*«.

A Fuseholders are designed so that it is difficult to put a fuse of any given class into a fuseholder intended for a current lower, or voltage higher, than that of the class to which the fuse belongs »*240.60(B)*«.

B Fuses must be plainly marked (by printing on or a label attached to the fuse barrel), showing the following: (1) ampere rating, (2) voltage rating, (3) interrupting rating if other than 10,000 amperes, (4) "current-limiting" where applicable, and (5) the name or trademark of the manufacturer. The interrupting rating is not required on fuses used for supplementary protection »*240.60(C)*«.

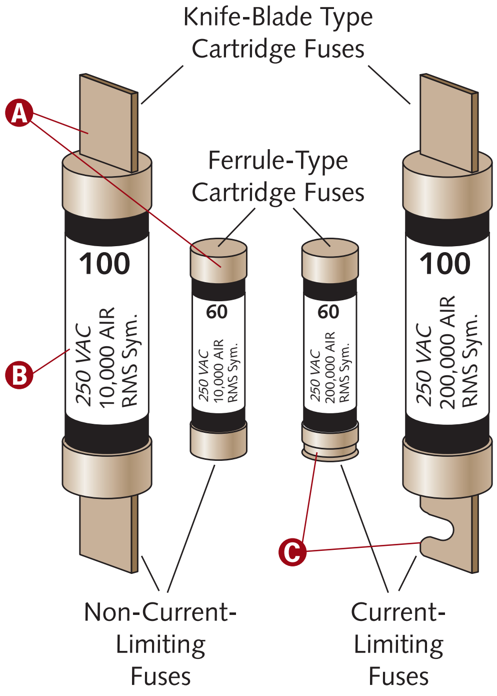
C Fuseholders for current-limiting fuses must not permit insertion of non-current-limiting fuses »*240.60(B)*«.

Caution

Cartridge fuses and fuseholders with a 300-volt rating can be used in the following: (1) circuits not exceeding 300 volts between conductors and (2) single-phase, line-to-neutral circuits supplied from a 3-phase, 4-wire solidly grounded neutral source with line-to-neutral voltage not exceeding 300 volts »*240.60(A)*«.

Note

Where fuses rated 1200 A or higher are installed, 240.67(A), (B), and (C) shall apply »***240.67***«.


Knife-Blade Type Cartridge Fuses
Ferrule-Type Cartridge Fuses
A
B
C
100
250 VAC 10,000 AIR RMS Sym.
60
250 VAC 10,000 AIR RMS Sym.
60
250 VAC 200,000 AIR RMS Sym.
100
250 VAC 200,000 AIR RMS Sym.
Non-Current-Limiting Fuses
Current-Limiting Fuses

Note

Class H cartridge fuses of the renewable type are only permitted as replacements in existing installations where there is no evidence of overfusing or tampering »***240.60(D)***«.

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Conductor Sizing

A For one-family dwellings and the individual dwelling units of two-family and multifamily dwellings, service and feeder conductors supplied by a single-phase, 120/240-volt system shall be permitted be sized in accordance with 310.12(A) through (D).

For a service rated 100 amperes through 400 amperes, the service conductors supplying the entire load associated with a one-family dwelling, or the service conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83% of the service rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied »*310.12(A)*«.

B In accordance with Table 310.12(A), the minimum size conductor is 2/0 AWG copper or 4/0 AWG aluminum.

Note

The grounded (neutral) conductor can be smaller than the ungrounded (hot) conductors, if 215.2, 220.61, and 230.42 requirements are met ***»310.12(D)«***.

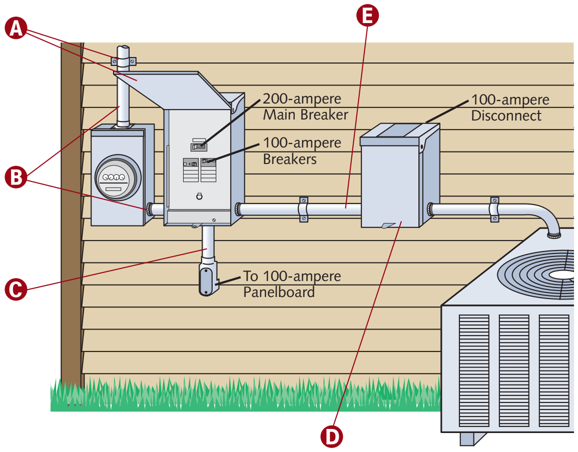
The grounded conductor shall not be smaller than specified in Table 250.102(C)(1) ***»250.24(D)(1)«***.

The feeder conductors to a dwelling unit shall not be required to have an allowable ampacity rating greater than specified in 310.12(A) or (B) ***»310.12(C)«***.

C It shall also be permissible to use Table 310.12(A) to size feeder conductors if they supply the entire load associated with the one-family dwelling. In this illustration, it is not permissible to use Table 310.12(A) to size these feeder conductors because they do not supply the entire load associated with this dwelling.

D Article 440 outlines provisions relating to disconnecting means, branch-circuit overload protection, and branch-circuit conductors for air-conditioning and refrigeration equipment.

E Conductor ampacities are found in Table 310.16.



Installation

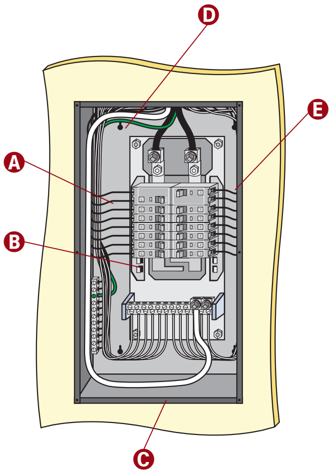
A Electric equipment must be installed in a professional and skillful manner »*110.12*«.

B All electric equipment internal parts (busbars, wiring terminals, insulators, etc.) must remain undamaged and uncontaminated by foreign materials (paint, plaster, cleaners, abrasives, corrosive residues, etc.). Equipment parts that are broken, bent, cut, corroded, impaired due to chemical action or heat, or otherwise damaged in such a way as to adversely affect safe operation or mechanical strength must not be used »*110.12(B)*«.

C Sections 312.100 through 312.102 itemize construction specifications for cabinets, cutout boxes, and meter socket enclosures.

D Cabinets and cutout boxes must have approved space to accommodate (without crowding) all installed conductors »*312.7*«.

E Conductor sizes are expressed in American Wire Gauge (AWG) or in circular mils »*110.6*«.



Note

The wiring space within enclosures for switches and overcurrent devices shall be permitted for other wiring and equipment subject to limitations for specific equipment as provided in 312.8(A) and (B) ***»312.8«***. The wiring space of enclosures for switches or overcurrent devices shall be permitted for conductors feeding through, spliced, or tapping off to other enclosures, switches, or overcurrent devices where all of the following conditions are met: (1) the total of all conductors installed at any cross section of the wiring space does not exceed 40% of the cross-sectional area of that space; (2) the total area of all conductors, splices, and taps installed at any cross section of the wiring space does not exceed 75% of the cross-sectional area of that space; (3) the bending space for conductors 4 AWG and larger complies with 314.28(A)(2); (4) a warning label complying with 110.21(B) is applied to the enclosure that identifies the closest disconnecting means for any feed-through conductors ***»312.8(A)«***. Power monitoring or energy management equipment shall be permitted to be installed in the wiring space of enclosures for switches or overcurrent devices where all of the following conditions are met: (1) the power monitoring or energy management equipment is identified as a field installable accessory as part of the listed equipment, or is a listed kit evaluated for field installation in switch or overcurrent device enclosures; (2) the total area of all conductors, splices, taps, and equipment at any cross section of the wiring space does not exceed 75% of the cross-sectional area of that space; and (3) conductors comply with 312.8(B)(3)(a) or (b) ***»312.8(B)«***.

Plug Fuses, Fuseholders, and Adapters

Ⓐ Plug fuses of 15-ampere and lower rating are identified by a hexagonal configuration in a prominent location (such as window cap or cap) to distinguish them from fuses of higher ampere ratings *»240.50(C)«*.

Ⓑ Type S adapters must fit Edison-base fuseholders *»240.54(A)«*.

Ⓒ Once inserted into a fuseholder, Type S adapters cannot be removed *»240.54(C)«*.

Ⓓ Type S fuses are classified at not over 125 volts, and 0 to 15 amperes, 16 to 20 amperes, or 21 to 30 amperes *»240.53(A)«*.

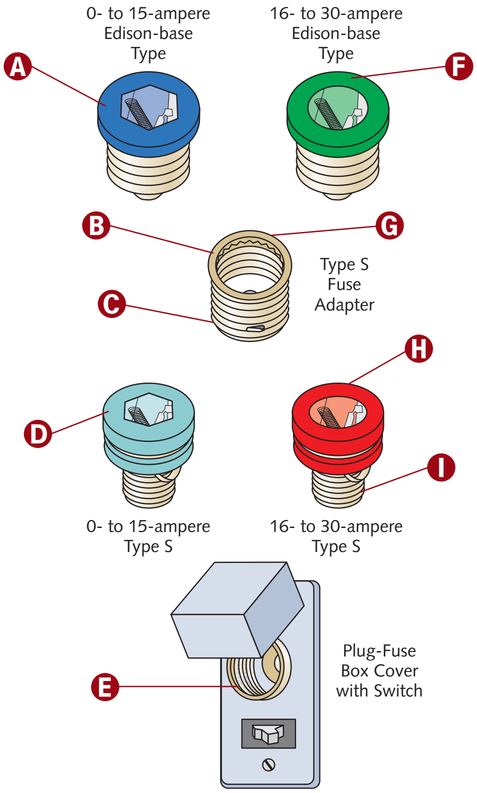
Ⓔ Fuseholders of the Edison-base type shall be installed only where they are made to accept Type S fuses by the use of adapters *»240.52«*.

Ⓕ Plug fuses rated 16 to 30 amperes are identified by means other than a hexagonal configuration.

Ⓖ Type S fuseholders and adapters are designed so that either the fuseholder itself or the fuseholder with a Type S adapter inserted can be used only for a Type S fuse *»240.54(B)«*.

Ⓗ Type S fuses of an ampere classification specified in 240.53(A) are not interchangeable with a lower-ampere classification. They can be used only in a Type S fuseholder or a fuseholder with a Type S adapter inserted *»240.53(B)«*.

Ⓘ Type S fuses, fuseholders, and adapters are designed to make tampering or shunting (bridging) difficult *»240.54(D)«*.



Note

The screw shell of a plug-type fuseholder must be connected to the circuit's load side ***»240.50(E)«***.

Warning

Plug fuses of the Edison-base type can be used only as replacements in existing installations exhibiting no evidence of overfusing or tampering *»240.51(B)«*.

Grounding

Grounded (Neutral) Conductor in the Service Disconnecting Means

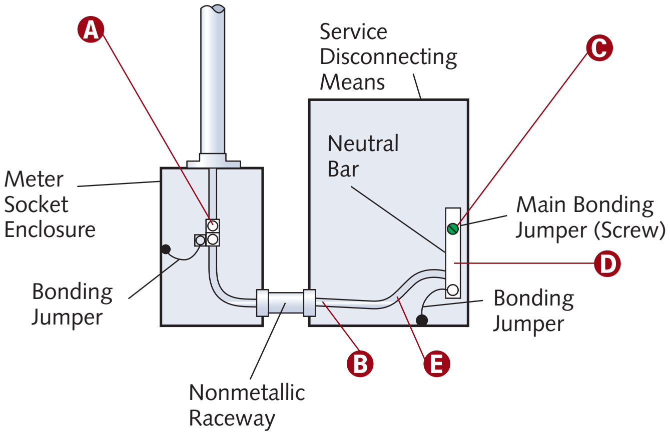
A Equipment grounding conductors, grounding electrode conductors, and bonding jumpers shall be connected by one or more of the following means: (1) listed pressure connectors; (2) terminal bars; (3) pressure connectors listed as grounding and bonding equipment; (4) exothermic welding process; (5) machine screw-type fasteners that engage not less than two threads or are secured with a nut; (6) thread-forming machine screws that engage not less than two threads in the enclosure; (7) connections that are part of a listed assembly; or (8) other listed means »*250.8(A)*«.

B An ac system grounded at any point and operating at 1000 volts or less must have a grounded conductor that is routed with the ungrounded conductors to each service disconnecting means and connected to each service disconnecting means grounded conductor(s) terminal or bus. A main bonding jumper shall connect the grounded conductor(s) to each service disconnecting means enclosure »*250.24(D)*«.

C A grounded system must have an unspliced main bonding jumper connecting the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor within each service disconnect enclosure in accordance with 250.28 »*250.24(C)*«.

D A single bar in the service-disconnect enclosure may serve as the neutral bar (or bus) and the equipment grounding terminal bar (or bus).

E The grounded conductor shall not be smaller than specified in Table 250.102(C)(1). »*250.24(D)(1)*«.



Note

The main bonding jumper (screw, strap, etc.) is installed only in service equipment and not in subpanels.

Main Bonding Jumper

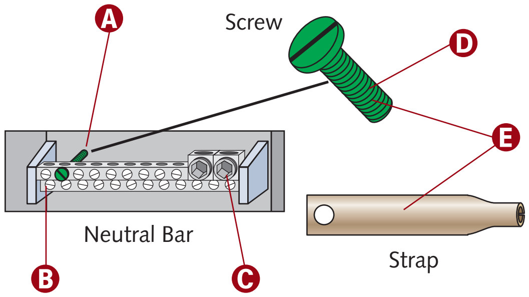
A A main bonding jumper is the connection between the grounded circuit conductor (neutral) and the equipment grounding conductor or the supply-side bonding jumper or both at the service »*Article 100*«.

B Main bonding jumpers and system bonding jumpers must be connected in the manner specified by the applicable provisions of 250.8 »*250.28(C)*«.

C A grounded system must have an unspliced main bonding jumper connecting the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor within each service disconnect enclosure »*250.24(C)*«.

D In cases where the main bonding jumper or a system bonding jumper is a screw only, it must be identified with a green finish that remains visible after installation »*250.28(B)*«.

E Main bonding jumpers and system bonding jumpers must be made of copper or other corrosion-resistant material; a wire, bus, screw, or similar suitable conductor is acceptable »*250.28(A)*«.



Note

Main bonding jumpers and system bonding jumpers shall not be smaller than specified in Table 250.102(C)(1). ***»250.28(D)(1)«***.

(Listed main bonding jumpers furnished with panelboards meet the provisions of 250.28.)

Caution

Panelboards listed as suitable for use as service equipment are furnished with a main bonding jumper that has not yet been installed. When using the panelboard as service equipment, install the main bonding jumper (screw, strap, etc.). When the panelboard is used for other purposes, such as a subpanel, do not install the main bonding jumper.

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Remote Panelboards (Subpanels)

A Unless grounded by connection to the grounded circuit conductor (permitted by 250.32, 250.140, and 250.142), non-current-carrying metal parts of equipment, raceways, and other enclosures if grounded, must be connected to an equipment grounding conductor by one of the following methods: (A) by connecting to any of the equipment grounding conductors permitted by 250.118, or (B) by connecting it to an equipment grounding conductor contained within the same raceway or cable or otherwise run with the circuit conductors »*250.134*«.

B Equipment grounding conductors can be bare, covered, or insulated. Individually covered or insulated equipment grounding conductors must have a continuous outer finish, either green or green with yellow stripe(s), except as otherwise permitted by Section 250.119 »*250.119(A)*«.

C Only in service disconnecting means can the neutral terminal bar be connected to the enclosure or equipment grounding terminal bar. In this illustration, the neutral bar is isolated from the equipment grounding system.

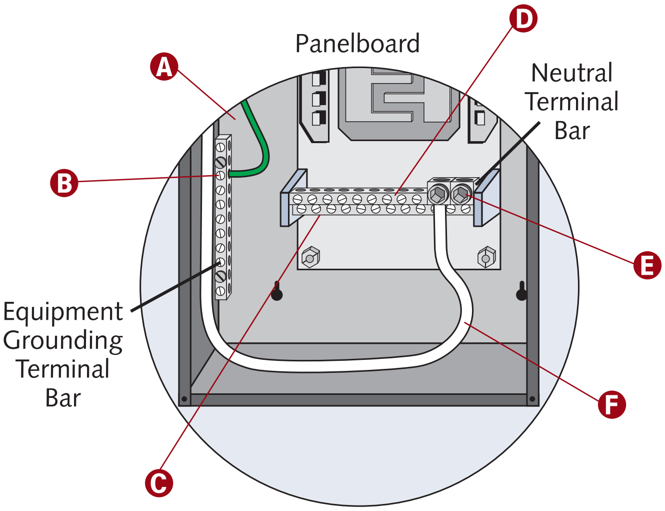
D A grounded circuit conductor shall not be used for grounding non-current-carrying metal parts of equipment on the load side of the service disconnecting means, unless an exception has been met »*250.142(B)*«.

E Panelboard cabinets and panelboard frames, if metal, must be in physical contact with one another and must be connected to an equipment grounding conductor. Equipment grounding conductors must not be connected to a terminal bar provided for grounded conductors or neutral conductors unless the bar is identified for that purpose and is located where interconnection between equipment grounding conductors and grounded circuit conductors comply with Article 250 »*408.40*«.

F A grounding connection must *not* be connected to normally non-current-carrying metal parts of equipment or to equipment grounding conductor(s) or be reconnected to ground on the load side of the service disconnecting means except as otherwise allowed in Article 250 »*250.24(B)*«.

Note

The bonding jumper (screw, strap, etc.) is installed only in the service disconnecting means and not in subpanels.



Grounding Electrode Conductor Connections

A The size of the grounding electrode conductor and bonding jumper(s) for connection of grounding electrodes shall not be smaller than given in Table 250.66, except as permitted in 250.66(A) through (C) »*250.66*«.

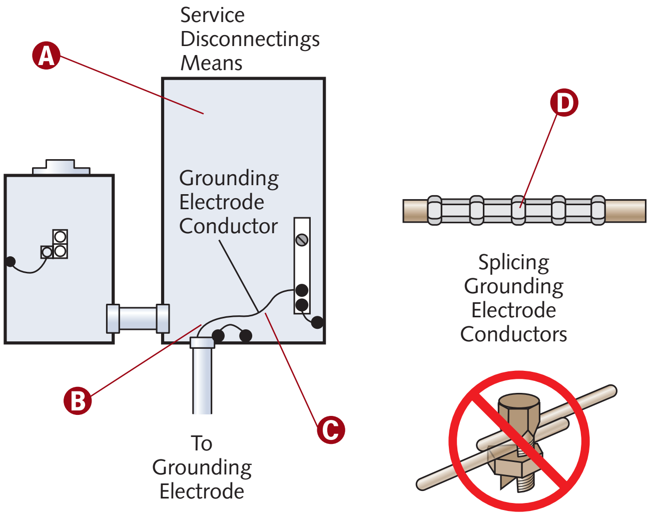
B A premises wiring system supplied by a grounded ac service must have a grounding electrode conductor connected to the grounded service conductor, at each service, in accordance with 250.24(A)(1) through (4) »*250.24(A)*«.

C A grounding electrode conductor must connect the equipment grounding conductors, the service-equipment enclosures, and, where the system is grounded, the grounded service conductor to the grounding electrode(s) as required by Part III of Article 250 »*250.24(E)*«.

D Splices in wire-type grounding electrode conductors are acceptable only if by means of irreversible compression-type connectors (listed as grounding and bonding equipment) or by the exothermic welding process »*250.64(C)(1)*«.

Note

The grounding electrode conductor connection shall be made at an accessible point from the load end of the overhead service conductors, service drop, underground service conductors, or service lateral to, including the terminal (or bus) to which the grounded service conductor is connected at the service disconnecting means »**250.24(A)(1)**«.


Service Disconnectings Means
A
Grounding Electrode Conductor
D
Splicing Grounding Electrode Conductors
B
C
To Grounding Electrode

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Methods of Bonding at the Service

Ⓐ One method is to bond equipment to the grounded service conductor in a 250.8-approved manner »*250.92(B)(1)*«.

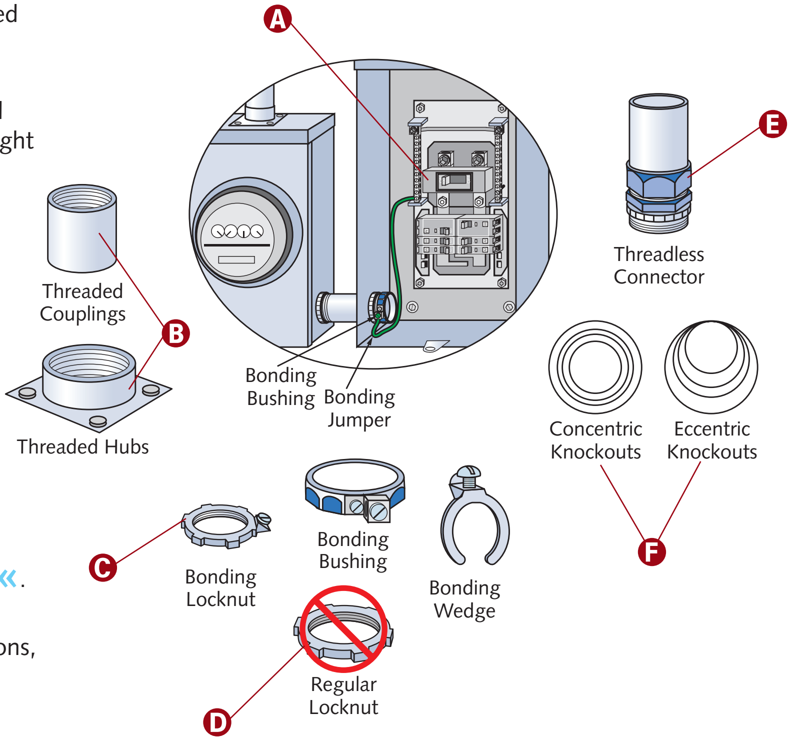
Ⓑ Connections using threaded couplings or threaded hubs on enclosures are permitted if made up wrenchtight »*250.92(B)(2)*«.

Ⓒ Listed devices, such as bonding-type locknuts, bushings, or bushings with bonding jumpers are also permitted to ensure electrical continuity at service equipment »*250.92(B)(4)*«.

Ⓓ Standard locknuts or bushings shall not be the sole means for bonding as required by 250.92(B), but shall be permitted to be installed to make a mechanical connection of the raceway(s) »*250.92(B)*«.

Ⓔ Threadless couplings and connectors are approved if made up tight for metal raceways and metal-clad cables. Standard locknuts and bushings shall not be used to bond these items »*250.92(B)(3)*«.

Ⓕ Bonding jumpers, which meet other Article 250 requirements, shall be used around impaired connections, such as reducing washers or oversized, concentric, or eccentric knockouts »*250.92(B)*«.


A
E
Threaded Couplings
Threadless Connector
B
Bonding Bushing
Bonding Jumper
Threaded Hubs
Concentric Knockouts
Eccentric Knockouts
Bonding Bushing
Bonding Wedge
C
Bonding Locknut
F
Regular Locknut
D

Bonding at the Service

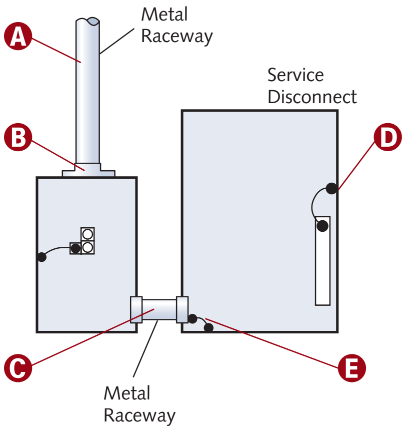
Ⓐ Bonding (bonded) is connected to establish electrical continuity and conductivity »*Article 100*«.

Ⓑ Threaded hubs are acceptable when bonding service equipment enclosures to threaded conduits or threadless connectors »*250.92(B)(2)* and *(3)*«.

Ⓒ All normally non-current-carrying metal parts of service equipment (such as raceways, enclosures containing service conductors, meter fittings, metal raceway, or armor enclosing a grounding electrode conductor) shall be bonded together »*250.92(A)*«.

Ⓓ Bonding, where necessary, must be provided to ensure not only electrical continuity but also ample capacity to safely conduct any fault current likely to be imposed »*250.90*«.

Ⓔ Electrical continuity at service equipment, service raceways, and service conductor enclosures must be accomplished by one of the approved methods in 250.92(B).


Metal Raceway
A
Service Disconnect
B
D
C
E
Metal Raceway

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Grounding Electrode System

Grounding electrodes covered in 250.52 include: (1) metal underground water pipe, (2) metal in-ground support structure(s), (3) concrete-encased electrode, (4) ground ring, (5) rod and pipe electrodes, (6) other listed electrodes, (7) plate electrodes, and (8) other local metal underground systems or structures. Although some of these grounding electrodes are described on this page, other electrodes from 250.52 are described on the following pages.

Exposed structural metal that is interconnected to form a metal building frame and is not intentionally grounded or bonded and is likely to become energized shall be bonded to any of the following: (1) service equipment enclosure; (2) grounded conductor at the service; (3) disconnecting means for buildings or structures supplied by a feeder or branch circuit; (4) grounding electrode conductor, if of sufficient size; (5) one or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is of sufficient size. The bonding conductor(s) or jumper(s) shall be sized in accordance with Table 250.102(C)(1) and installed in accordance with 250.64(A), (B), and (E). The points of attachment of the bonding jumper(s) shall be accessible unless installed in compliance with 250.68(A), Exception No. 2 »*250.104(C)*«.

A One or more metal in-ground support structure(s) in direct contact with the earth vertically for 10 ft (3.0 m) or more, with or without concrete encasement. If multiple metal in-ground support structures are present at a building or a structure, it shall be permissible to bond only one into the grounding electrode system »*250.52(A)(2)*«. Metal in-ground support structures include, but are not limited to, pilings, casings, and other structural metal »*250.52(A)(2) Informational Note*«.

B A ground ring, which encircles the building or structure in direct contact with the earth at a depth of at least 2½ ft (750 mm) below the surface of the earth, consisting of at least 20 ft (6.0 m) of bare copper conductor not smaller than 2 AWG, is allowed »*250.52(A)(4)* and *250.53(F)*«.

C A concrete-encased electrode shall be encased by at least 2 in. (50 mm) of concrete, located horizontally within that portion of a concrete foundation or footing that is in direct contact with the earth or within vertical foundations or structural components or members that are in direct contact with the earth. The electrode must consist of one or more bare or zinc galvanized or other electrically conductive coated rebar of not less than ½ in. (13 mm) in diameter and 20 ft (6.0 m) continuous length or consisting of at least 20 ft (6.0 m) of bare copper conductor not smaller than 4 AWG. Multiple pieces of rebar can be connected together by steel tie wires, exothermic welding, welding, or other effective means to create a 20 ft (6.0 m) or greater length »*250.52(A)(3)*«.

D Grounding electrode conductors and bonding jumpers shall be permitted to be connected to the metal structural frame of a building to be used as a conductor to interconnect electrodes that are part of the grounding electrode system, or as a grounding electrode conductor. Grounding electrode conductors and bonding jumpers shall also be permitted to be connected to a rebar-type concrete-encased electrode installed in accordance with 250.52(A)(3) with an additional rebar section extended from its location within the concrete to an accessible location that is not subject to corrosion shall be permitted for connection of grounding electrode conductors and bonding jumpers. The rebar extension shall not be exposed to contact with the earth without corrosion protection »*250.68(C)(2)* and *(3)*«.

Note

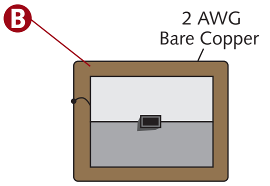
All grounding electrodes as described in 250.52(A)(1) through (A)(7) that are present at each building or structure served must be bonded together to form the grounding electrode system. Where none of these grounding electrodes exist, one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) must be installed and used »***250.50***«.

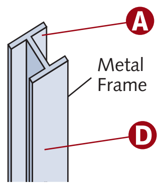
Note

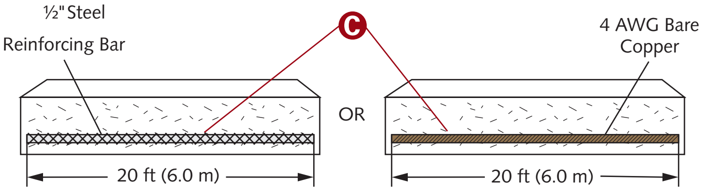
Hold-down bolts securing the structural steel column that are connected to a concrete-encased electrode that complies with 250.52(A)(3) and is located in the support footing or foundation shall be permitted to connect the metal structural frame of a building or structure to the concrete encased grounding electrode. The hold-down bolts shall be connected to the concrete-encased electrode by welding, exothermic welding, the usual steel tie wires, or other approved means »***250.68(C)(2)***«.

Warning

A concrete foundation or footing is not considered to be in "direct contact" with the earth if the concrete is installed with insulation, vapor barriers, films, or similar items that separate the concrete from the earth »*250.52(A)(3) Informational Note*«.







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Metal Water Pipe Electrodes

Ⓐ A metal underground water pipe must be in direct contact with the earth for a minimum of 10 ft (3.0 m) (including any metal well casing effectively bonded to the pipe) and electrically continuous (or made so by bonding around insulating joints or insulating pipe) to the points of connection of the grounding electrode conductor and the bonding conductor(s) or jumper(s), if installed »*250.52(A)(1)*«.

Ⓑ Grounding path continuity, or the bonding connection to interior piping, must not rely on water meters, filtering devices, or similar equipment »*250.53(D)(1)*«.

Ⓒ Bonding jumper(s) shall be installed in accordance with 250.64(A), (B), and (E), shall be sized in accordance with 250.66, and shall be connected as specified in 250.70 »*250.53(C)*«.

Ⓓ Interior metal water piping that is electrically continuous with a metal underground water pipe electrode and is located not more than 5 ft (1.52 m) from the point of entrance to the building shall be permitted to extend the connection to an electrode(s). Interior metal water piping located more than 5 ft (1.52 m) from the point of entrance to the building shall not be used as a conductor »*250.68(C)(1)*«.

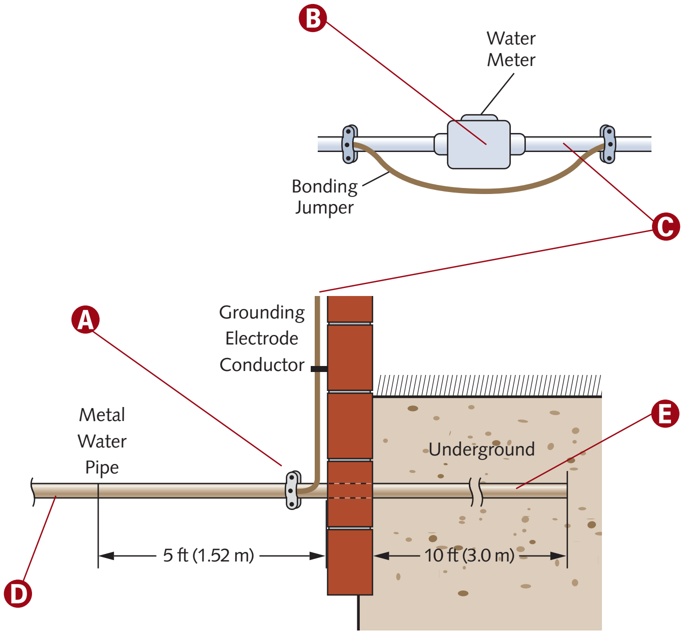
Ⓔ A metal underground water pipe shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). If the supplemental electrode is of the rod, pipe, or plate type, it shall comply with 250.53(A). The supplemental electrode shall be bonded to one of the following: (1) grounding electrode conductor; (2) grounded service-entrance conductor; (3) nonflexible grounded service raceway; (4) any grounded service enclosure; or (5) as provided by 250.32(B) »*250.53(D)(2)*«.

Note

A metal underground water pipe shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). If the supplemental electrode is of the rod, pipe, or plate type, it shall comply with 250.53(A). The supplemental electrode shall be bonded to one of the following: (1) grounding electrode conductor; (2) grounded service-entrance conductor; (3) nonflexible grounded service raceway; (4) any grounded service enclosure; or (5) as provided by 250.32(B) ***»250.53(D)(2)«***.

Note

The grounding electrode conductor can be run to any convenient grounding electrode available in the grounding electrode system where the other electrode(s), if any, is connected by bonding jumpers that are installed in accordance with 250.53(C). Grounding electrode conductor(s) can also be run to one or more grounding electrode(s) individually. It must be sized for the largest grounding electrode conductor required among all the electrodes being connected ***»250.64(F)«***. Bonding jumper(s) from grounding electrode(s) can also be connected to an aluminum or copper busbar where installed in accordance with 250.64(F)(3).



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Rod, Pipe, and Plate Electrodes

If none of the grounding electrodes specified in 250.52(A)(1) through (A)(7) exist, one or more of the grounding electrodes specified in 250.52(A)(4) through (A)(8) must be installed and used »*250.50*«.

Pipe or conduit electrodes shall not be smaller than trade size ¾ in., and, if steel, shall have a galvanized outer surface (or shall be otherwise metal-coated or corrosion-protected) »*250.52(A)(5)(1)*«.

If practicable, rod, pipe, and plate electrodes shall be embedded below permanent moisture level. Rod, pipe, and plate electrodes shall be free from nonconductive coatings such as paint or enamel »*250.53(A)(1)*«.

Aluminum grounding electrodes are not permitted »*250.52(B)(2)*«.

Ⓐ The electrode's upper end must be flush with or below ground level unless the aboveground end and the grounding electrode conductor attachment are adequately protected against physical damage as specified in 250.10 »*250.53(A)(4)*«.

Ⓑ Rod-type grounding electrodes of stainless steel and copper or zinc-coated steel must be at least ⅝ in. (15.87 mm) in diameter unless listed »*250.52(A)(5)(2)*«.

Ⓒ In multiple electrode configurations of the type specified in 250.52(A)(5) or (A)(7), each electrode of one grounding system (including that used for strike termination devices) must be at least 6 ft (1.83 m) from any other electrode of another grounding system. »*250.53(B)*«.

Ⓓ In accordance with 250.53(A)(2), if a single rod, pipe, or plate electrode is installed, it must be supplemented by an additional electrode. But, if the single rod, pipe, or plate electrode has a resistance to earth of 25 ohms or less, the supplemental electrode is not required »*250.53(A)(2) Exception*«.

Ⓔ A metal underground gas piping system *shall not* be used as a grounding electrode »*250.52(B)(1)*«.

Ⓕ At least 8 ft (2.44 m) of electrode length must be in contact with the soil »*250.53(A)(4)*«.

Ⓖ Where rock bottom is encountered, the electrode can be driven at an oblique angle not to exceed 45° from vertical »*250.53(A)(4)*«.

Ⓗ Where rock bottom is encountered at an angle up to 45°, the electrode can be buried in a trench that is at least 2½ ft (750 mm) deep »*250.53(A)(4)*«.

Ⓘ Each plate electrode must expose at least 2 ft^2 (0.186 m^2) of surface to exterior soil »*250.52(A)(7)*«. (One square foot of surface area on each side of a 1 ft × 1 ft plate equals 2 square feet.)

Ⓙ If multiple rod, pipe, or plate electrodes are installed to meet the requirements of 250.53, they shall not be less than 6 ft (1.8 m) apart »*250.53(A)(3)*«.

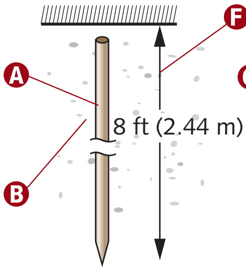
The paralleling efficiency of rods is increased by spacing them twice the length of the longest rod »*250.53(A)(3) Informational Note*«.

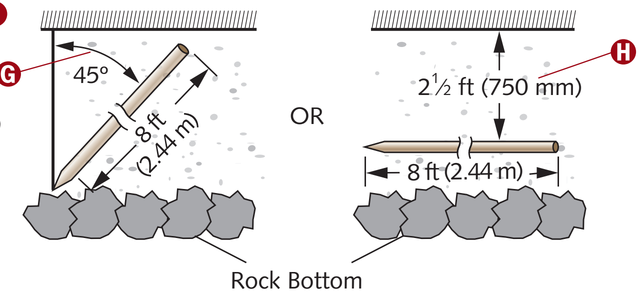
Ⓚ Electrodes of bare or electrically conductive coated iron or steel plates must be at least ¼ in. (6.4 mm) thick, while solid, uncoated nonferrous metal plates must be at least 0.06 in. (1.5 mm) thick »*250.52(A)(7)*«.

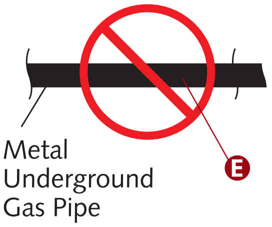
Ⓛ Plate electrodes must be installed at least 2½ ft (750 mm) below the earth's surface »*250.53(A)(5)*«.

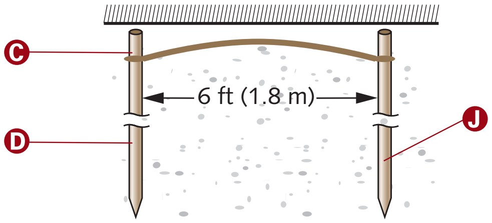
Note

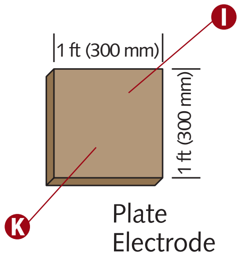
A single rod, pipe, or plate electrode shall be supplemented by an additional electrode of a type specified in 250.52(A)(2) through (A)(8). The supplemental electrode shall be permitted to be bonded to one of the following: (1) rod, pipe, or plate electrode; (2) grounding electrode conductor; (3) grounded service-entrance conductor; (4) nonflexible grounded service raceway; or (5) any grounded service enclosure »***250.53(A)(2)***«.

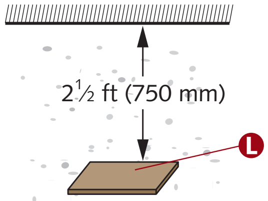












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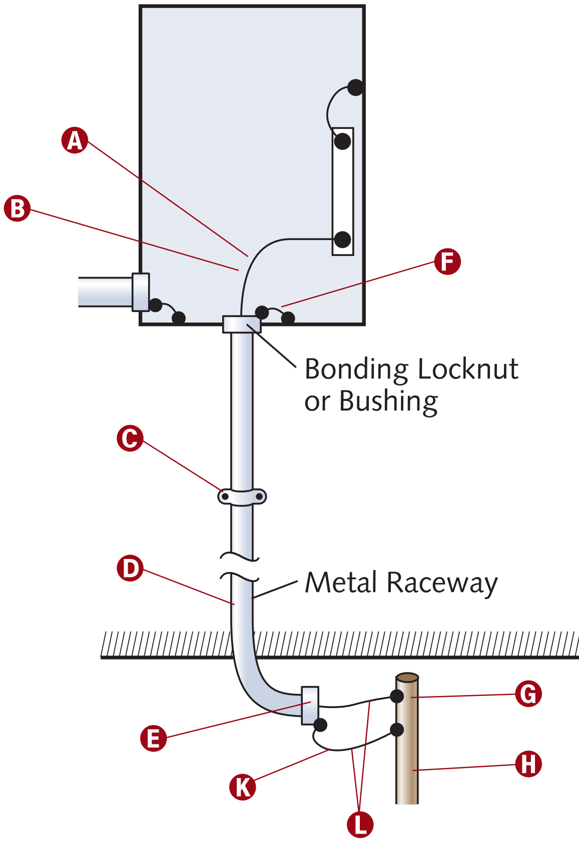
Grounding Electrode Conductor

The grounding electrode conductor must be made of copper, aluminum, copper-clad aluminum, or the items as permitted in 250.68(C). The material selected shall be resistant to any corrosive condition existing at the installation or shall be protected against corrosion. Conductors of the wire type shall be solid, stranded, insulated, covered, or bare »*250.62*«.

Bare or covered aluminum or copper-clad aluminum conductors without an extruded polymeric covering shall not be installed where subject to corrosive conditions or be installed in direct contact with concrete. Aluminum or copper-clad aluminum conductors external to buildings or equipment enclosures shall not be terminated within 18 in. (450 mm) of the earth. Terminations made within outdoor enclosures that are listed and identified for the environment shall be permitted within 18 in. (450 mm) of the bottom of the enclosure »*250.64(A)*«.

A A grounding electrode conductor must be used to connect the equipment grounding conductors, the service-equipment enclosures, and, in a grounded system, the grounded service conductor to the grounding electrode(s) as required by Part III of Article 250. The conductor shall be sized in accordance with 250.66 »*250.24(E)*«.

B The grounding electrode conductor must be installed in one continuous length (without a splice or joint), unless as permitted in 250.30(A)(5) and (A)(6), 250.30(B)(1), and 250.68(C) »*250.64(C)*«.



C Where exposed, a grounding electrode conductor (or its enclosure) must be securely fastened to the surface on which it is carried »*250.64(B)*«.

D If a raceway is used as protection for a grounding electrode conductor, the installation must comply with appropriate raceway article requirements »*250.64(E)(4)*«.

E Ferrous metal raceways and enclosures shall be bonded at each end of the raceway or enclosure to the grounding electrode or grounding electrode conductor to create an electrically parallel path »*250.64(E)(1)*«.

F Ferrous metal raceways and enclosures for grounding electrode conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode and shall be fastened securely to the ground clamp (or fitting) »*250.64(E)(1)*«.

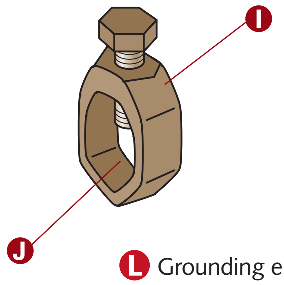
G The grounding conductor must be connected to the grounding electrode by exothermic welding or by listed means, such as lugs, pressure connectors, clamps, etc. Connections depending on solder shall not be used »*250.70(A)*«.

H Only one conductor can be connected to the grounding electrode by a single clamp or fitting, unless it is listed for multiple conductors »*250.70(A)*«.

I This is one variety of ground-rod clamp listed for direct burial.

J Ground clamps must be listed for the grounding electrode and grounding electrode conductor materials and, if used on pipe (rod, or other buried electrodes), must also be listed for direct soil burial or concrete encasement »*250.70(A)*«.

K The bonding jumper for a grounding electrode conductor raceway or cable armor must be the same size (or larger) than the largest enclosed grounding electrode conductor »*250.64(E)(3)*«.



L Grounding electrode conductors and grounding electrode bonding jumpers in contact with the earth shall not be required to comply with 300.5 or 305.15 but shall be buried or otherwise protected if subject to physical damage »*250.64(B)(4)*«.

Note

Bonding shall be in compliance with 250.92(B) and ensured by one of the methods in 250.92(B)(2) through (B)(4) ***»250.64(E)(2)«***. See 250.92(B) for bonding methods at the service.

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Grounding Electrode Conductor Sizing

Where exposed, a grounding electrode conductor or its enclosure shall be securely fastened to the surface on which it is carried. A 6 AWG or larger grounding electrode conductor (copper or aluminum) must be protected if exposed to physical damage. A 6 AWG or larger grounding electrode conductor not exposed to physical damage can run along the surface of the building construction without metal covering or protection. A 6 AWG or larger copper or aluminum grounding electrode conductor exposed to physical damage shall be protected in rigid metal conduit (RMC), intermediate metal conduit (IMC), Schedule 80 rigid polyvinyl chloride conduit (PVC), reinforced thermosetting resin conduit Type XW (RTRC-XW), electrical metallic tubing (EMT), or cable armor »*250.64(B), (B)(1),* and *(B)(2)*«.

Grounding electrode conductors smaller than 6 AWG shall be protected in RMC, IMC, Schedule 80 PVC, RTRC, EMT, or cable armor »*250.64(B)(3)*«.

Ⓐ The connection of a grounding electrode conductor at the service, at each building or structure where supplied by a feeder(s) or branch circuit(s), or at a separately derived system and associated bonding jumper(s) shall be made as specified 250.68(A) through (C) »*250.68*«.

Ⓑ A 4 AWG copper (or 2 AWG aluminum or copper-clad aluminum) grounding electrode conductor is required if the service-entrance conductors are 2/0 AWG or 3/0 AWG copper »*Table 250.66*«.

Ⓒ The interior metal water piping that is electrically continuous with a metal underground water pipe electrode can be used as a conductor to interconnect electrodes that are part of the grounding electrode system, but only if it is located not more than 5 ft (1.52 m) from the point of entrance to the building »*250.68(C)(1)*«.

Ⓓ To ensure an effective grounding path for a metal piping system used as a grounding electrode, bonding must be provided as necessary around insulated joints as well as around any equipment likely to be disconnected for repairs or replacement. Bonding jumpers shall be of sufficient length to permit removal of such equipment while retaining the integrity of the grounding path »*250.68(B)*«.

Ⓔ If the grounding electrode conductor or bonding jumper connected to a single or multiple rod, pipe, or plate electrode(s), or any combination thereof, as provided in 250.52(A)(5) or (A)(7), does not extend on to other types of electrodes that require a larger size conductor, the grounding electrode conductor shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum wire »*250.66(A)*«. Grounding electrode conductors and grounding electrode bonding jumpers in contact with the earth shall not be required to comply with 300.5 or 305.15, but shall be buried or otherwise protected if subject to physical damage »*250.64(B)(4)*«.

Ⓕ If the grounding electrode conductor or bonding jumper connected to a single or multiple concrete-encased electrode(s) as described in 250.52(A)(3), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than 4 AWG copper wire »*250.66(B)*«.

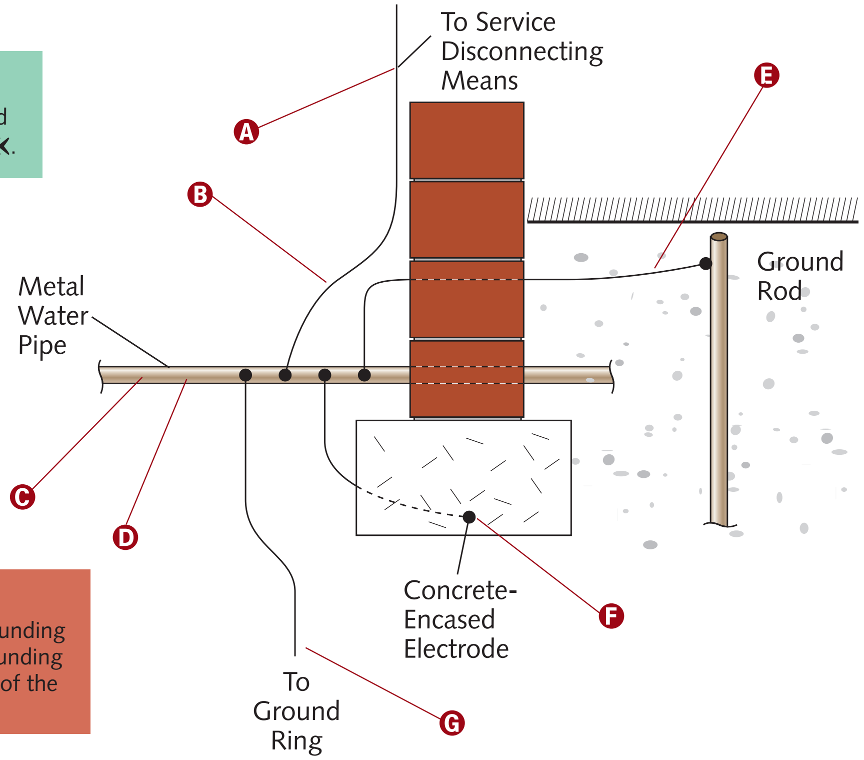
Ⓖ If the grounding electrode conductor or bonding jumper connected to a ground ring, as described in 250.52(A)(4), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than the conductor used for the ground ring »*250.66(C)*«.

Note

Grounding electrode conductors can be installed on or through framing members »*250.64(B)*«.

Caution

Although the NEC does not require the grounding electrode conductor used as the sole connection to a ground rod(s) to be larger than 6 AWG copper, many power companies specify larger grounding electrode conductors. Always verify service requirements with the local AHJ and electric service provider.



Caution

All mechanical elements used to terminate a grounding electrode conductor or bonding jumper to a grounding electrode shall be accessible unless meeting one of the two exceptions »*250.68(A)*«.

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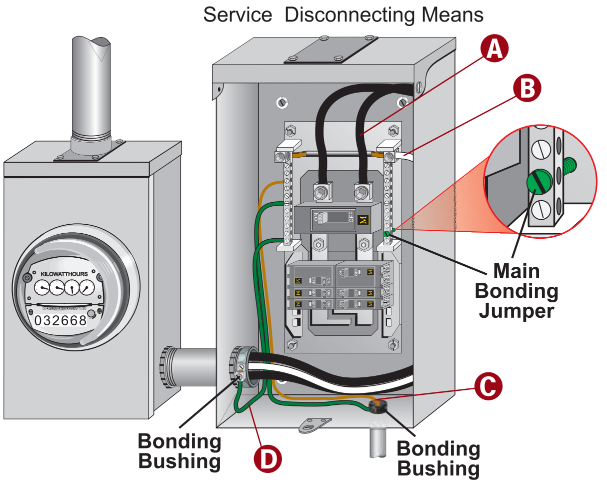
Supply-Side Bonding Jumper

A Grounding electrode conductor and equipment bonding jumper sizes on the supply side of the service are determined by service-entrance conductor sizes.

B Unit 8 explains grounded (neutral) conductor sizing.

C The size of the grounding electrode conductor and bonding jumper(s) for connection of grounding electrodes shall not be smaller than given in Table 250.66, except as permitted in 250.66(A) through (C) »*250.66*«.

D The supply-side bonding jumper shall not be smaller than specified in Table 250.102(C)(1) »*250.102(C)(1)*«.



Caution

Metal piping system(s), including gas piping, with the potential to become energized must be bonded to any of the following: (1) equipment grounding conductor for the circuit that is likely to energize the piping system; (2) service equipment enclosure; (3) grounded conductor at the service; (4) grounding electrode conductor, if of sufficient size; or (5) one or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is of sufficient size. The bonding conductor(s) or jumper(s) must be sized in accordance with Table 250.122 by using the rating of the circuit that is likely to energize the piping system(s). The points of attachment of the bonding jumper(s) shall be accessible »*250.104(B)*«.

Note

The metal water piping system(s) installed in or attached to a building or structure shall be bonded to any of the following: (1) service equipment enclosure; (2) grounded conductor at the service; (3) grounding electrode conductor if of sufficient size; (4) one or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is of sufficient size. The bonding jumper must be sized in accordance with Table 250.102(C)(1) and installed in accordance with 250.64(A), (B), and (E). The bonding jumper's point of attachment must be accessible ***»250.104(A) and (A)(1)«***.

Equipment Bonding Jumper on the Load Side of an Overcurrent Device

The equipment bonding jumper on the load side of an overcurrent device(s) shall be sized, in accordance with 250.122 »*250.102(D)*«.

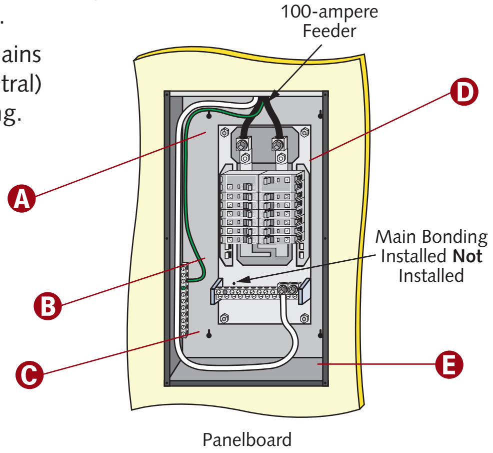
A A panelboard (on the load side of an overcurrent device) protected by a 100-ampere overcurrent protection device (circuit breaker or fuse) requires an 8 AWG copper equipment grounding conductor »*Table 250.122*«.

B Wire-type copper, aluminum, or copper-clad aluminum equipment grounding conductors must not be less than shown in Table 250.122, but in no case are they required to be larger than the circuit conductors supplying the equipment. Where a raceway, cable armor, or sheath is used as the equipment grounding conductor (as provided in 250.118 and 250.134[1]), it must comply with 250.4(A)(5) or (B)(4) »*250.122(A)*«.

C Metal panelboard cabinets and frames must be connected to an equipment grounding conductor and in physical contact with each other. Where the panelboard is used with nonmetallic raceway (or cable), or where separate grounding conductors are provided, a terminal bar for the grounding conductors must be secured within the cabinet. The terminal bar must be bonded to the metal cabinet and panelboard frame. Otherwise it shall be connected to the equipment grounding conductor that is run with the conductors feeding the panelboard »*408.40*«.

D Equipment grounding conductor and equipment bonding jumper sizes (on the load side of an overcurrent device) are determined by the size of the overcurrent device that protects the equipment.

E Unit 8 explains grounded (neutral) conductor sizing.



Note

If ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or 310.15(C), wire-type equipment grounding conductors, if installed, shall be increased in size proportionately to the increase in circular mil area of the ungrounded conductors ***»250.122(B)«***.

An equipment grounding conductor run with (or enclosing) the circuit conductors must be one of those listed in 250.118(A).

Intersystem Bonding Termination

An intersystem bonding termination (IBT) for connecting intersystem bonding conductors shall be provided external to enclosures at the service equipment or metering equipment enclosure and at the disconnecting means for any additional buildings or structures. If an IBT is used, it shall comply with the following:

(1) Be accessible for connection and inspection.
(2) Consist of a set of terminals with the capacity for connection of not less than three intersystem bonding conductors.
(3) Not interfere with opening the enclosure for a service, building or structure disconnecting means, or metering equipment.
(4) At the service equipment, be securely mounted and electrically connected to a metal enclosure for the service equipment, to a metal meter enclosure, or to an exposed nonflexible metallic service raceway, or be connected to the metal enclosure for the grounding electrode conductor with a minimum 6 AWG copper conductor
(5) At the disconnecting means for a building or structure that is supplied by a feeder or branch circuit, be electrically connected to the metal enclosure for the building or structure disconnecting means, or be connected to the metal enclosure for the grounding electrode conductor with a minimum 6 AWG copper conductor.
(6) The terminals shall be listed as grounding and bonding equipment »*250.94(A)*«. Connections to an aluminum or copper busbar shall be permitted where meeting the conditions in 250.94(B).

A Shall be located at the service equipment or metering equipment and the disconnecting means for any buildings or structures that are supplied by a feeder or branch circuit and shall not interfere with opening doors or covers.

B Shall have at least three terminals for intersystem bonding conductors.

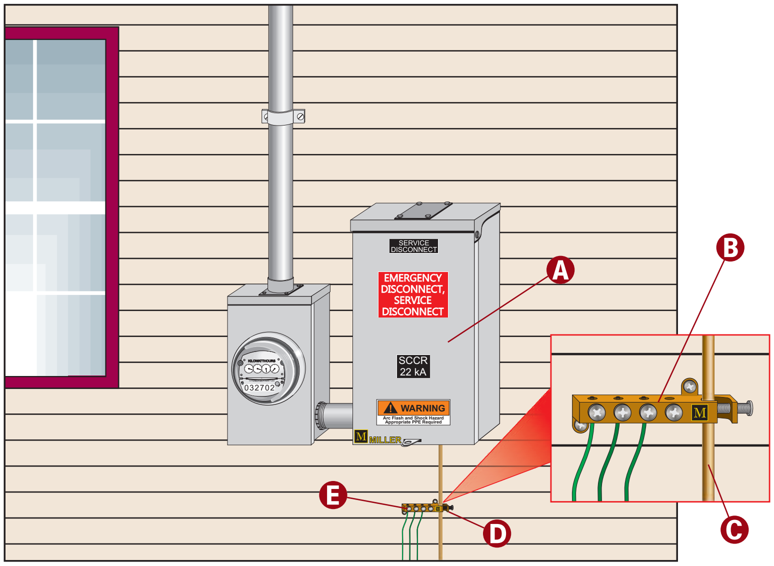
C If connected to the metal enclosure for the grounding electrode conductor, the minimum size is 6 AWG copper.

D Shall be accessible for connection and inspection.

E The terminals shall be listed as grounding and bonding equipment.

Note

Exception: In existing buildings or structures where any of the intersystem bonding and grounding electrode conductors required by 770.100(B)(2), 800.100(B)(2), 810.21(F)(2), and 820.100 exist, installation of the intersystem bonding termination is not required. An accessible means external to enclosures for connecting intersystem bonding and grounding electrode conductors shall be permitted at the service equipment and at the disconnecting means for any additional buildings or structures by at least one of the following means:
(1) Exposed nonflexible metallic raceways
(2) An exposed grounding electrode conductor
(3) Approved means for the external connection of a copper or other corrosion-resistant bonding or grounding electrode conductor to the grounded raceway or equipment.


KILOWATTHOURS
032702
SERVICE DISCONNECT
EMERGENCY DISCONNECT, SERVICE DISCONNECT
SCCR 22 kA
WARNING
Arc Flash and Shock Hazard Appropriate PPE Required
M MILLER
A
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Separate Building or Structure – Grounding Electrode Not Required

Besides other requirements in the National Electrical Code, installations in separate buildings and structures must meet requirements in Article 225. Requirements in Article 225 cover outside branch circuits and feeders.

Means shall be provided for disconnecting all ungrounded conductors that supply or pass through the building or structure »*225.31(A)*«. The disconnecting means specified in 225.31 shall be a circuit breaker, molded case switch, general-use switch, snap switch, or other approved means. Where applied in accordance with 250.32(B), Exception No. 1, the disconnecting means shall be suitable for use as service equipment »*225.36*«.

A building is defined as a structure that stands alone or that is separated from adjoining structures by fire walls »*Article 100*«.

A A structure is defined as that which is built or constructed, other than equipment »*Article 100*«.

B A grounding electrode shall not be required where only a single branch circuit, including a multiwire branch circuit, supplies the building or structure, and the branch circuit includes an equipment grounding conductor for grounding the normally non-current-carrying metal parts of equipment »*250.32(A) Exception*«.

C If a one-family dwelling has a detached garage with electric power, at least one wall switch–controlled lighting outlet shall be installed to provide illumination on the exterior side of outdoor entrances or exits with grade level access. A vehicle door in a garage shall not be considered as an outdoor entrance or exit »*210.70(A)(2)(2)*«.

D In each detached garage with electric power, at least one receptacle outlet shall be installed in each vehicle bay and not more than 5½ ft (1.7 m) above the floor »*210.52(G)(1)*«. In each accessory building with electric power, at least one receptacle outlet shall be installed »*210.52(G)(2)*«.

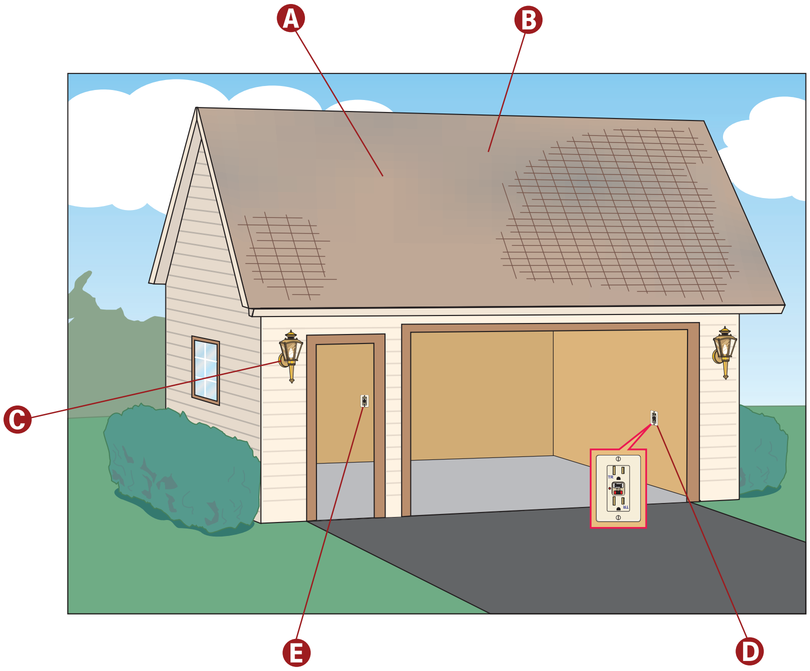
E At least one receptacle outlet shall be installed in each vehicle bay and not more than 5½ ft (1.7 m) above the floor »*210.52(G)(1)*«.

Note

At least one wall switch–controlled lighting outlet shall be installed in detached garages with electric power »***210.70(A)(2)(1)***«.

Note

In addition to the number of branch circuits required by other parts of Article 210, at least one 120-volt, 20-ampere branch circuit shall be installed to supply receptacle outlets in attached garages and in detached garages with electric power. This circuit shall have no other outlets unless the circuit supplies outdoor receptacle outlets »***210.11(C)(4)* and *Exception No. 1***«.



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Separate Buildings or Structures

Besides other requirements in the NEC, installations in separate buildings and structures must meet requirements in Article 225. Requirements in Article 225 cover outside branch circuits and feeders.

A Buildings or structures supplied by feeders or branch circuits must have a grounding electrode system and grounding electrode conductor installed in accordance with Part III of Article 250 »*250.32(A)*«.

B Means shall be provided for disconnecting all ungrounded conductors that supply or pass through the building or structure »*225.31(A)*«.

C The disconnecting means shall be installed either inside or outside of the building or structure served or where the conductors pass through the building or structure. The disconnecting means shall be at a readily accessible location nearest the point of entrance of the conductors »*225.31(B)*«.

Note

There is an exception for installations made in compliance with previous editions of the *NEC* that permitted alternative connections. See Exception No. 1 to 250.32(B)(1).

Where the disconnecting means specified in 225.31 is applied in accordance with 250.32(B) Exception No. 1, the disconnecting means shall be suitable for use as service equipment »*225.36*«.

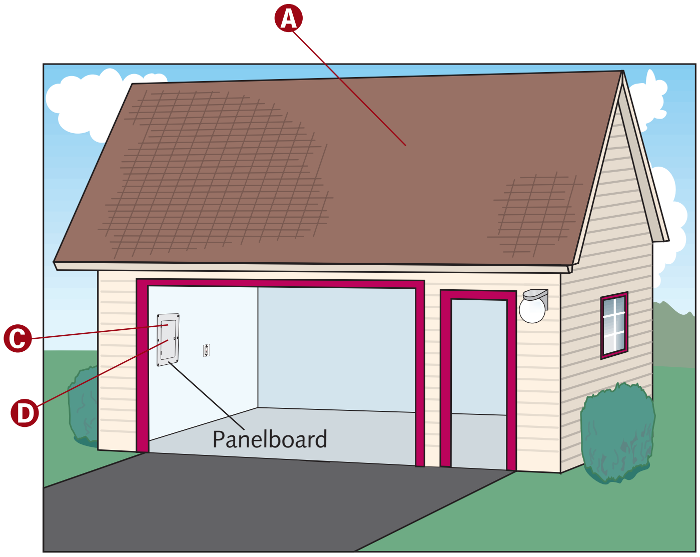
D The disconnecting means specified in 225.31 shall be comprised of a circuit breaker, molded case switch, general-use switch, snap switch, or other approved means »*225.36*«.

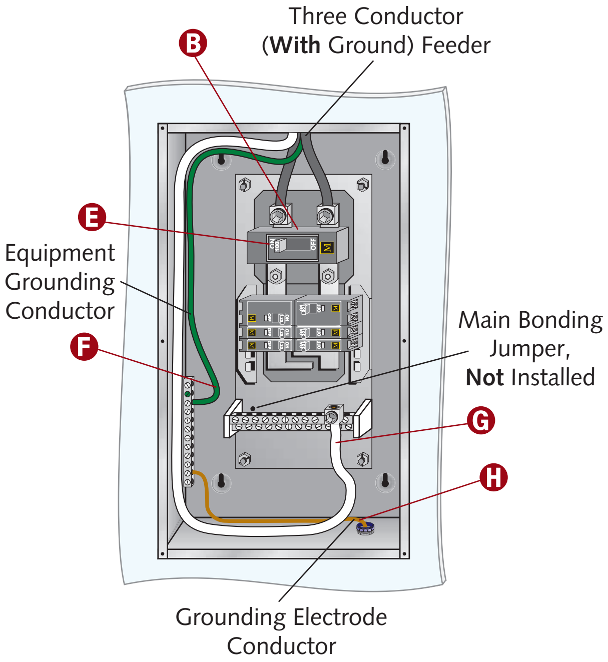
E The building or structure disconnecting means shall plainly indicate whether it is in the open or closed position »*225.38(D)*«.

F An equipment grounding conductor, as described in 250.118, shall be run with the supply conductors and connected to the building or structure disconnecting means and to the grounding electrode(s). The equipment grounding conductor shall be used for grounding or bonding or equipment, structures, or frames required to be grounded or bonded. The equipment grounding conductor must be sized in accordance with 250.122 »*250.32(B)(1)*«.

G Any installed grounded conductor shall not be connected to the equipment grounding conductor or to the grounding electrode(s) »*250.32(B)(1)*«.

H The size of the grounding electrode conductor to the grounding electrode(s) shall not be smaller than given in 250.66, based on the largest ungrounded supply conductor. The installation shall comply with Part III of Article 250 »*250.32(E)*«.





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Preventing Objectionable Current

Normally non-current-carrying electrically conductive materials that are likely to become energized must be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path »*250.4(A)(4)*«.

Currents resulting from abnormal conditions, such as ground faults, are not classified as objectionable current for the purpose specified in 250.6(A) and (B) »*250.6(C)*«.

Ⓐ Normally non-current-carrying conductive materials enclosing electrical conductors (or equipment), or forming part of such equipment, must be connected to earth so as to limit the voltage to ground on these materials »*250.4(A)(2)*«.

Ⓑ If the use of multiple grounding connections results in objectionable current and the requirements of 250.4(A)(5) or (B)(4) are met, one or more of the following alterations shall be permitted: (1) discontinue one or more, but not all, of such grounding or bonding connections; (2) change the location of the grounding or bonding connections; (3) interrupt the continuity of the conductor (or conductive path) causing the objectionable current; and (4) take other remedial and approved action »*250.6(B)*«.

Ⓒ The grounding and bonding of electric systems, circuit conductors, surge arresters, surge-protective devices and conductive normally non-current-carrying metal parts of equipment must be installed and arranged in a manner that prevents objectionable current »*250.6(A)*«.

Caution

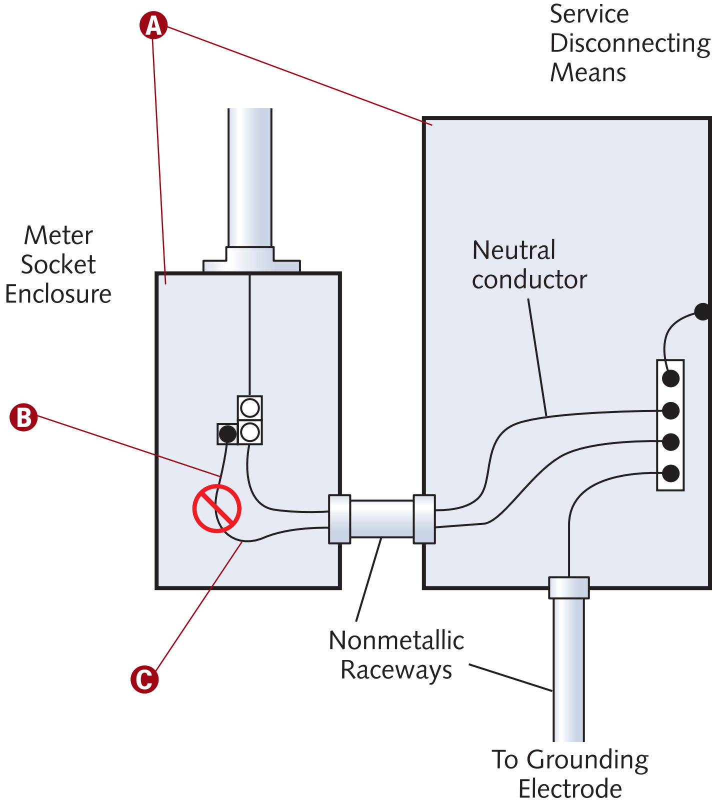
Connecting a grounded (neutral) and grounding conductor in parallel creates objectionable current on the grounding conductor, because the unbalanced current flows through both the grounded and grounding conductor. Should the grounded conductor lose its continuity (become disconnected), the grounding conductor would then carry all of the unbalanced (neutral) current. A hazard would exist if the grounding conductor's ampacity rating is less than the current flowing through it.

Note

Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for high-impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault occurs to the electrical supply source. The earth shall not be considered as an effective ground-fault current path »***250.4(A)(5)***«.

Note

Normally non-current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path »***250.4(A)(3)***«.



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Summary

- A service mast must safely withstand the strain imposed by service-drop conductors.
- Nothing except electrical service-drop conductors can be attached to the service mast.
- Wiring methods permitted for services are listed in 230.43.
- Service-drop conductor vertical ground clearances are found in 230.24(B)
- Service-drop conductor roof clearances are in 230.24(A).
- A minimum of 6½ ft (2.0 m) of workspace headroom is required around service equipment and panelboards.
- A minimum frontal workspace width is 30 in. (762 mm) for service equipment and panelboards; the depth of this workspace must be at least 3 ft (914 mm).
- Panelboards are mounted in cabinets or cutout boxes.
- Each service disconnect must be permanently marked identifying it as a service disconnect.
- For one- and two-family dwelling units, the service disconnecting means or emergency meter disconnect(s) must be located outdoors in a readily accessible location.
- The service disconnecting means shall not consist of two to six switches or sets of circuit breakers, or a combination of two to six switches and sets of circuit breakers, mounted in a single enclosure.
- It shall be permissible to use Table 310.12(A) to size 120/240-volt, single-phase dwelling services and certain feeders rated 100 through 400 amps.
- If the installation does not meet the specifications in 310.12(A) and (B) the conductors shall be sized in accordance with Table 310.16.
- Electric equipment must be installed in a neat and professional manner.
- Grounding and bonding conductors must be connected by listed means.
- The grounded (neutral) conductor is isolated from the equipment grounding conductor in subpanels.
- Grounding electrode conductors are sized from 250.66 and Table 250.66.
- Use Table 250.102(C)(1) to size main bonding jumpers, system bonding jumpers, and supply side bonding jumpers.
- Equipment grounding conductors and bonding jumpers, on the load side of the service, are sized according to 250.122 and Table 250.122.
- All non-current-carrying metal parts of service equipment must be bonded together.
- Grounding electrode systems (and conductors) are located in Part III of Article 250.
- Panelboards in separate buildings or structures must be installed according to 250.32 provisions.

Unit 9 Competency Test

NEC® Reference **Answer**

___________ ___________ 1. The point of attachment of the service-drop conductors to a building must not be less than ___________ ft above finish grade.

___________ ___________ 2. The supply-side bonding jumper shall not be smaller than the sizes shown in Table ___________ for grounding electrode conductors.

___________ ___________ 3. Service conductors run above the top level of a window shall be:

a) 8 ft above a window.

b) considered readily accessible

c) 3 ft above a window.

d) permitted to be less than 3 ft above the window.

___________ ___________ 4. Every circuit breaker having an interrupting rating other than ___________ amperes shall have its interrupting rating shown on the circuit breaker.

___________ ___________ 5. Energized parts of service equipment that are not enclosed shall be installed on a ___________ and guarded in accordance with 110.18 and 110.27.

I. switchboard

II. panelboard

III. control board

a) II only b) I or II only c) II or III only d) I, II, or III

***NEC*® Reference** **Answer**

____________ ____________ 6. In addition to the requirement of 408.30, a panelboard shall be protected by an overcurrent protective device having a rating not greater than ____________.

____________ ____________ 7. Service-entrance cables shall be supported by straps or other approved means within ____________ of every service head, gooseneck, or connection to a raceway or enclosure.

a) 1 ft b) 6 ft c) 12 ft d) 30 ft

____________ ____________ 8. Bonding jumpers meeting the other requirements of Article 250 shall be used around impaired connections, such as reducing washers or oversized ____________ knockouts.

____________ ____________ 9. Residential 240-volt service-drop conductors must have a vertical clearance above a driveway of at least ____________ ft.

____________ ____________ 10. A ground ring used as a grounding electrode and encircling the building, in direct contact with the earth, must consist of at least ____________ ft of bare copper conductor not smaller than 2 AWG.

____________ ____________ 11. Plug fuses of 15-ampere and lower rating shall be identified by a(n) ____________ configuration of the window, cap, or other prominent part to distinguish them from fuses of higher ampere ratings.

____________ ____________ 12. Where more than one rod, pipe, or plate grounding electrodes are used, each electrode of one grounding system (including that used for strike termination devices) shall not be less than ____________ ft from any other electrode of another grounding system.

____________ ____________ 13. Every circuit and circuit modification in a panelboard shall be legibly identified as to its ____________ purpose or use.

____________ ____________ 14. Service heads on raceways or service-entrance cables and ____________ in service-entrance cables shall be located above the point of attachment of the service-drop or overhead service conductors to the building or other structure.

____________ ____________ 15. The width of the working space in front of electric equipment operating at 1000 volts, nominal, or less to ground shall be the width of the equipment or ____________ in., whichever is greater.

____________ ____________ 16. Which of the following is not a true statement concerning an equipment grounding conductor?

a) Under certain conditions, equipment grounding conductors shall be required to be larger than circuit conductors supplying the equipment.

b) One equipment grounding conductor may serve multiple circuits.

c) Under certain conditions, equipment grounding conductors may be run in parallel.

d) The size of equipment grounding conductors shall be increased where ungrounded conductors are increased in size.

____________ ____________ 17. The minimum height of working space for equipment operating at 1000 volts, nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized shall be ____________ ft or the height of the equipment, whichever is greater.

____________ ____________ 18. Service-drop conductors shall have a vertical clearance of not less than ____________ ft above the roof surface.

____________ ____________ 19. In damp or wet locations, surface-type cabinets, cutout boxes, and meter socket enclosures shall be so placed or equipped as to prevent moisture or water from entering and accumulating within them, and mounted so there is at least ____________ in. airspace between the enclosure and the wall or other supporting surface.

____________ ____________ 20. Other equipment or support structures, such as concrete pads, associated with the electrical installation located above or below the electrical installation shall be permitted to extend not more than ____________ beyond the front of the electrical equipment.

a) 0 in. b) 6 in. c) 12 in. d) 24 in.

____________ ____________ 21. What size copper equipment bonding jumper is required for a 200-ampere panelboard located on the load side of the overcurrent device? (The conductors feeding the panelboard are 3/0 AWG copper conductors.)

NEC® Reference **Answer**

___________ ___________ 22. Plug fuses of the Edison-base type shall be classified at not over 125 volts and ___________ amperes and below.

___________ ___________ 23. A ___________ is a conductor used to connect the system grounded conductor or the equipment to a grounding electrode or to a point on the grounding electrode system.

___________ ___________ 24. If a single rod, pipe, or plate grounding electrode has a resistance to earth of ___________ or less, a supplemental grounding electrode shall not be required.

___________ ___________ 25. A disconnecting means serving a hermetic refrigerant motor compressor shall be selected on the basis of the nameplate rated-load current or branch-circuit selection current, whichever is greater, and locked-rotor current, respectively, of the motor compressor. The ampere rating shall be at least ___________ of the nameplate rated-load current or branch-circuit selection current, whichever is greater.

___________ ___________ 26. Circuit breakers rated ___________ or less and 1000 volts or less shall have the ampere rating molded, stamped, etched, or similarly marked into their handles or escutcheon areas.

___________ ___________ 27. A dwelling has a 175-ampere service that is fed with THW copper conductors. The service is supplied by a single-phase, 120/240-volt system. What is the minimum size copper grounding electrode conductor?

___________ ___________ 28. The ___________ is the connection between the grounded circuit conductor and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service.

___________ ___________ 29. Which of the following is not a standard ampere rating for fuses?

a) 25 amperes b) 50 amperes c) 75 amperes d) 601 amperes

___________ ___________ 30. If multiple rod, pipe, or plate electrodes are installed to meet the installation requirements of the grounding electrode system, they shall not be less than ___________ ft apart.

___________ ___________ 31. Where the ungrounded supply conductors are larger than 1100 kcmil copper, the main bonding jumper shall have an area not less than ___________% of the area of the largest ungrounded supply conductor.

___________ ___________ 32. Service conductors are the conductors from the service point to the ___________.

___________ ___________ 33. The minimum depth of working space for a 120/240-volt panelboard, with exposed live parts on one side and grounded parts on the other, shall be at least ___________ ft.

___________ ___________ 34. Each plate electrode shall expose not less than ___________ ft^2 of surface to exterior soil and shall be installed not less than ___________ ft below the surface of the earth.

___________ ___________ 35. Where installed on the outside of a raceway, the length of the equipment bonding jumper shall not exceed ___________ ft and shall be routed with the raceway.

___________ ___________ 36. An intersystem bonding termination shall consist of a set of terminals with the capacity for connection of not less than ___________ intersystem bonding conductors.

___________ ___________ 37. Where approved, rigid metal conduit shall not be required to be securely fastened within ___________ ft of the service head for above-the-roof termination of a mast.

___________ ___________ 38. A service disconnect installed for a one-family dwelling unit as the service disconnect and also as the emergency disconnect shall be marked ___________.

___________ ___________ 39. A grounded conductor must not be connected to ___________ of equipment or to equipment grounding conductor(s) or be reconnected to ground on the load side of the service disconnecting means except as otherwise allowed in Article 250.

___________ ___________ 40. The grounding and bonding of electrical systems, circuit conductors, surge arresters, surge-protective devices, and conductive normally non-current-carrying materials (and equipment) must be installed and arranged in a manner that prevents ___________.

___________ ___________ 41. A ___________ is defined as that which is built or constructed, other than equipment.

Section 3

Multifamily Dwellings

Unit 10

Comprehensive Provisions

Objectives

After studying this unit, the student should be able to:

- clarify the general receptacle and lighting installation provisions for multifamily dwellings since are almost identical to those for one-family structures.
- summarize the exceptions permitting the installation of more than one service on a multifamily building.
- explain the provisions limiting the number of service disconnecting means to only six.
- recall the provision requiring that each multifamily dwelling occupant have access to the unit's service disconnecting means.
- define service lateral and recall provisions pertaining to service laterals.
- summarize service conductor vertical clearance requirements.
- determine when Table 310.12(A) can be used to size service and feeder conductors.
- recall that balconies, decks, and porches within 4 in. (102 mm) of a dwelling unit are required to have at least one receptacle outlet accessible from the balcony, deck, or porch.
- select the appropriate voltage-drop formula, insert the proper data, and calculate the correct answer.
- recall applicable provisions from other units in this book that directly relate to multifamily dwellings.

Introduction

A multifamily dwelling is a building containing three or more dwelling units. Apartments or condominiums are examples of multifamily dwellings. They can be any size, from one-story structures containing three units to high-rise buildings containing hundreds of units. One-family dwelling units (covered in Section 2 of this book) contain fundamental provisions essential to all dwelling units, whether one-, two-, or multifamily. Most of the general installation requirements (such as receptacle and switch placement), as well as most of the specific provisions (such as kitchen and bathroom regulations) pertain to all dwelling occupancies. A few requirements in this unit are specific to multifamily dwellings. Service provisions pertaining to multifamily dwellings, such as the maximum number of service disconnecting means, are explained in this unit, which also includes a brief description and explanation of voltage-drop formulas. A thorough understanding of one-family dwelling requirements is essential to understanding those for multifamily dwellings.

Plans (Blueprints)

Partial Site Plan

A For individual dwelling units of multifamily dwellings, service and feeder conductors supplied by a single-phase, 120/240-volt system shall be permitted to be sized in accordance with 310.12(A) through (D). For individual dwelling units of multifamily dwellings, single-phase feeder conductors consisting of two ungrounded conductors and the neutral conductor from a 208Y/120 volt system shall be permitted to be sized in accordance with 310.12(B) through (D). For a feeder rated 100 through 400 amperes, the feeder conductors supplying the entire load associated with an individual dwelling unit in a multifamily dwelling, shall be permitted to have an ampacity not less than 83% of the feeder rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied »*310.12* and *310.12(B)*«.

In a multiple-occupancy building, each occupant must have access to the unit's service disconnecting means, unless electric service and electrical maintenance are provided by building management »*230.72(C)*«.

B A laundry receptacle is not required if one of the applicable exceptions is met »*210.52(F)*«.

C With few exceptions, general lighting provisions are the same for both one- and multifamily dwellings »*210.70*«.

D Use 220.82 to perform optional method load calculations for individual feeders in each unit of multifamily dwellings.

E Clubhouse and swimming pool load calculations are determined in accordance with Article 220, Part III provisions.

The clubhouse is exempt from dwelling unit(s) provisions.

If any portion of the clubhouse is designed or intended for the assembly of more than 99 persons, that portion must comply with Article 518 provisions.

F General receptacle installation provisions for multifamily dwellings are almost identical to those for one-family dwellings »*210.52*«.

G Use Part III of Article 220 to perform standard method load calculations for both feeders and services. Use 220.84 to perform multifamily dwelling optional load calculations for feeders or services consisting of three or more units.

H Swimming pool provisions are contained in Article 680. Swimming pool motor loads are computed in accordance with 430.22 and 430.24 requirements.

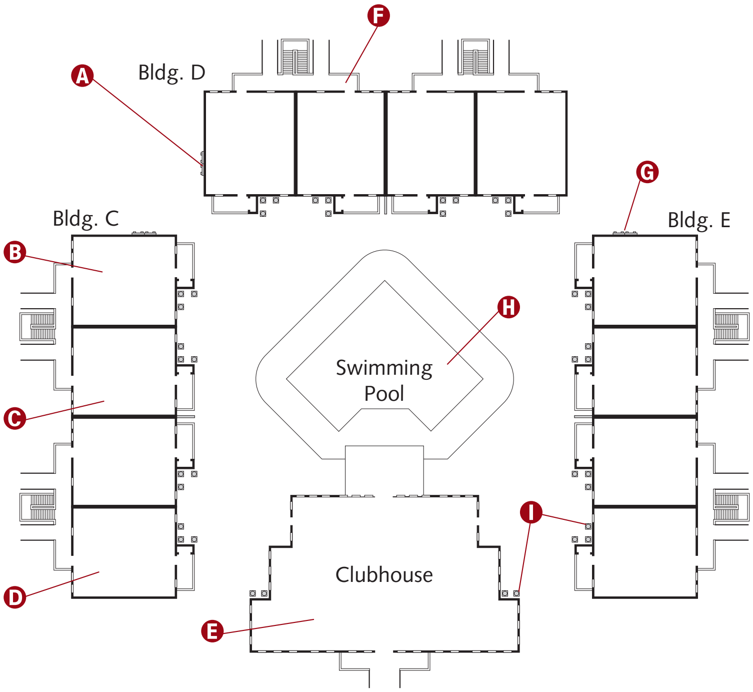
I Air-conditioning and refrigeration equipment provisions are found in Article 440.

Note

If calculating by the optional method, house loads must be calculated in accordance with Article 220, Part III, and must be in addition to the dwelling unit loads calculated by Table 220.84(B) demand factors »***220.84(B)***«.

Caution

At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed in an accessible location within 25 ft (7.5 m) of the indoor electrical service equipment. The required receptacle outlet shall be located within the same room or area as the service equipment »*210.63(B)* and *(B)(1)*«. This requirement also applies where equipment, other than service equipment, requires dedicated equipment space as specified in 110.26(E).



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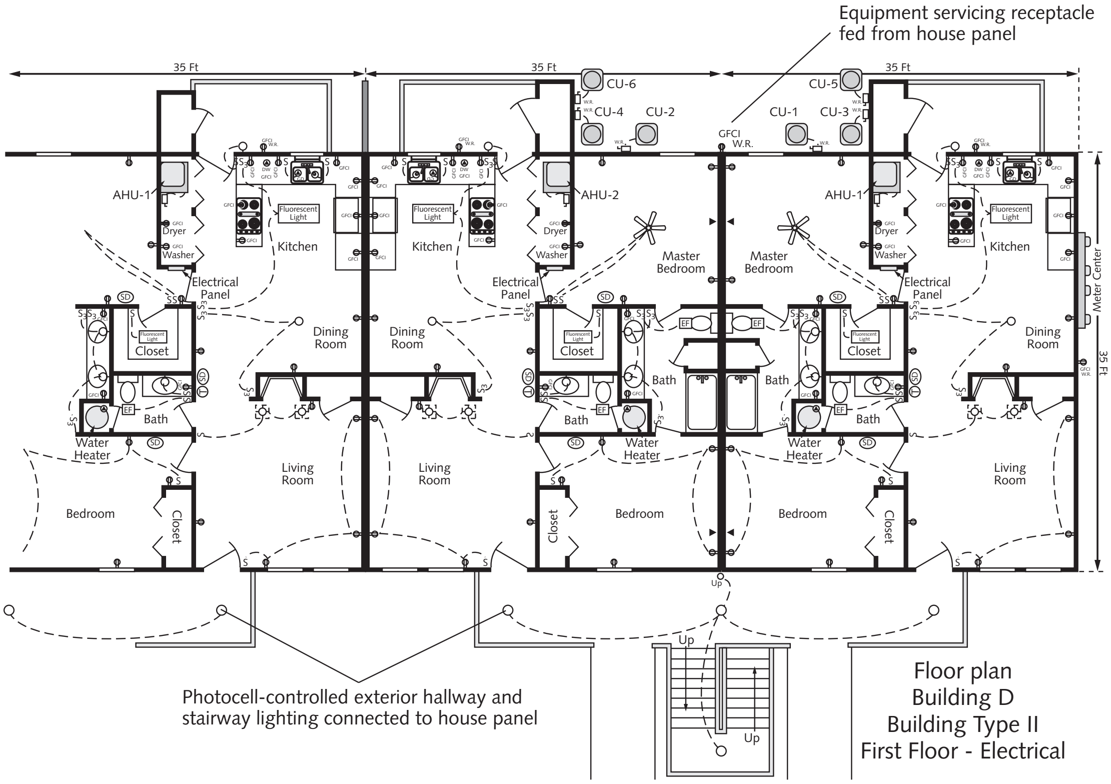
Electrical Plan



Equipment servicing receptacle fed from house panel

Photocell-controlled exterior hallway and stairway lighting connected to house panel

Floor plan
Building D
Building Type II
First Floor - Electrical

Services

Maximum Number of Services

A Vertical service-drop conductor clearances are covered in Unit 9 of this book.

B A building (or other structure) shall be supplied by only one service unless permitted in 230.2(A) through (D) ›› *230.2* ‹‹.

C Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following: (1) separate enclosures with a main service disconnecting means in each enclosure; (2) panelboards with a main service disconnecting means in each panelboard enclosure; (3) switchboard(s) where there is only one service disconnect in each separate vertical section with barriers provided between each vertical section; (4) service disconnects in switchgear, transfer switches, or metering centers where each disconnect is located in a separate compartment; (5) metering centers with a main service disconnecting means in each metering center; or (6) motor control center(s) where there is only one service disconnect in a motor control center unit and a maximum of two service disconnects provided in a single motor control center with barriers provided between each motor control center unit or compartment containing a service disconnect ›› *230.71(B)* ‹‹.

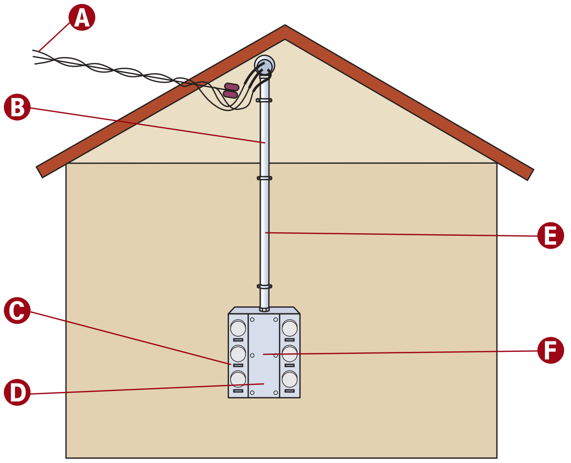
D Auxiliary gutter provisions are located in Article 366.

Note

Unit 9 explains equipment working space, 110.26.

E The conductors and equipment connecting the serving utility to the wiring system of the premises is called the service ›› *Article 100* ‹‹.

F Wiring spaces can be supplemented by auxiliary gutters at meter centers, distribution centers, switchboards, and similar points and may enclose conductors or busbars. Auxiliary gutters, however, shall not be used to enclose switches, overcurrent devices, appliances, or similar equipment ›› *Article 100* and *366.12* ‹‹.



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Warning

All services supplying dwelling units shall be provided with a surge-protective device (SPD). The SPD shall be an integral part of the service equipment or shall be located immediately adjacent thereto unless it is located at each next level distribution equipment downstream toward the load. The SPD shall be a Type 1 or Type 2 SPD. When replacing service equipment, all requirements 230.67 shall be met. SPDs shall have a nominal discharge current rating (In) of not less than 10 kA »*230.67(A)* through *(D)*«.

Caution

Each service shall have only one disconnecting means unless the requirements of 230.71(B) are met »*230.71*«.

Maximum Number of Disconnects per Service

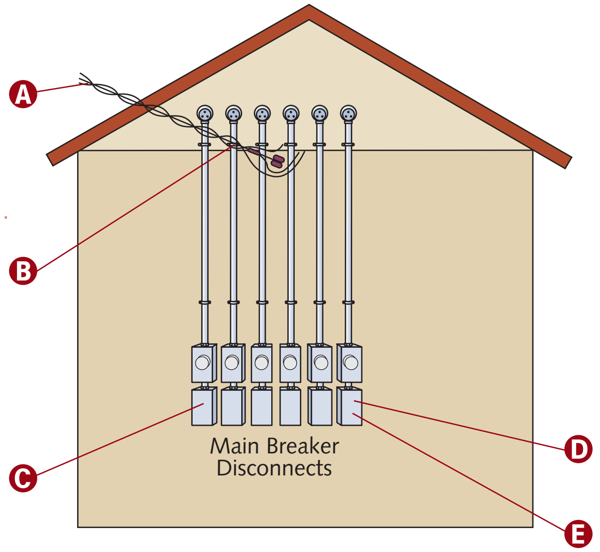
A Section 230.40 basic requirements state that each service drop (or lateral) must supply only one set of service-entrance conductors. However, several exceptions exist.

B Two to six service disconnecting means in separate enclosures, grouped at one location and supplying separate loads from one service drop, set of overhead service conductors, set of underground service conductors, or service lateral, can be supplied by one set of service-entrance conductors to each or several such service equipment enclosures »*230.40 Exception No. 2*«.

C There shall be no more than six sets of disconnects per service grouped in a single location »*230.71(B)*«.

D The two to six disconnects, as permitted in 230.71, must be grouped »*230.72(A)*«.

E Each disconnect must be marked to indicate the load served »*230.72(A)*«.



Note

For the purpose of 230.71, a disconnecting means used solely for the control circuit of the ground-fault protection system, installed as part of the listed equipment, is not considered a service disconnecting means »***230.71(A)(3)***«.

Two Disconnects Supplying Twelve Units

A Conductors must have sufficient ampacity to carry the current for the load as calculated in accordance with Article 220 »*230.23(A)*«.

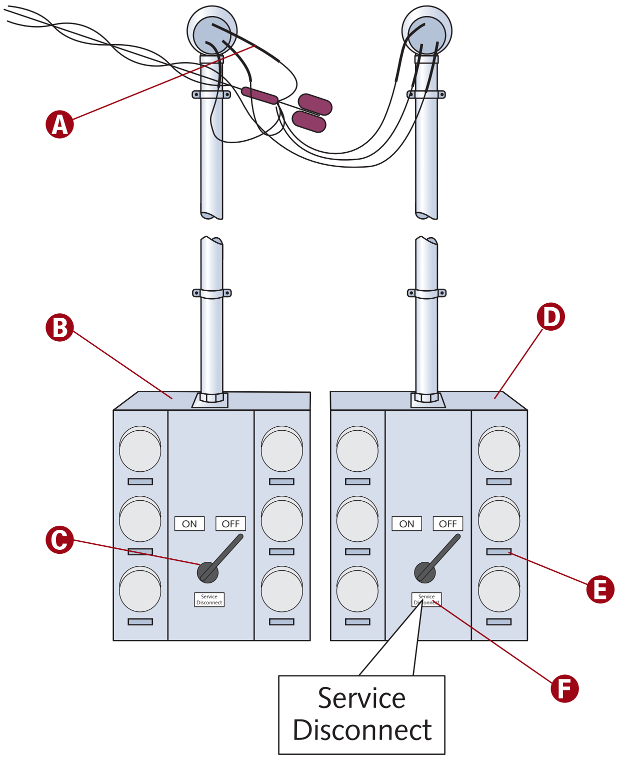
B Many possible combinations exist for these twelve units: one main disconnect feeding all twelve units; three main disconnects feeding twelve units (four units per disconnect); and six main disconnects feeding twelve units (two units per disconnect), to name a few. The arrangement of service disconnects is not critical, as long as no more than six operations of the hand disconnect all of the service conductors.

C There must be no more than six disconnects per service grouped »*230.72(A)*«.

D If the service disconnecting means consists of more than one switch or circuit breaker, as permitted by 230.71, the combined ratings of all the switches or circuit breakers used must meet the rating requirements of 230.79 »*230.80*«.

E In a multiple-occupancy building, each occupant must have access to his or her unit's service disconnecting means »*230.72(C)*«.

F Each service disconnect must be permanently marked to identify it as a service disconnect »*230.70(B)*«.



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Note

In a multiple-occupancy building where electric service and electrical maintenance are provided by building management, under continuous supervision, the service disconnecting means supplying more than one occupancy can be accessible only to authorized management personnel ***»230.72(C) Exception«***.

More Than One Service

A building or other structure can have another service for fire pumps where a separate service is required »*230.2(A)(1)*«.

A building or other structure can have another service for emergency systems, legally required or optional standby systems, interconnected electric power production sources, or systems designed for connection of multiple sources of supply for the purpose of enhanced reliability »*230.2(A)(2)* through *(6)*«.

By special permission, in multiple-occupancy buildings where there is no space available for service equipment accessible to all occupants, additional services shall be permitted »*230.2(B)(1)*«. Special permission is the written consent of the AHJ »*Article 100*«.

Multiple services are permitted where the capacity requirements are in excess of 2000 amperes at a supply voltage of 1000 volts or less »*230.2(C)(1)*«.

Ⓐ If the load requirements of a single-phase installation are greater than the serving agency normally supplies through one service, multiple services are permitted »*230.2(C)(2)*«.

Ⓑ Where a building or structure is supplied by multiple services or by any combination of branch circuits, feeders, and services, a permanent plaque (or directory) must be installed at each service disconnect location denoting all other services, feeders, and branch circuits supplying that building as well as the area served by each. See 225.37 »*230.2(E)*«.

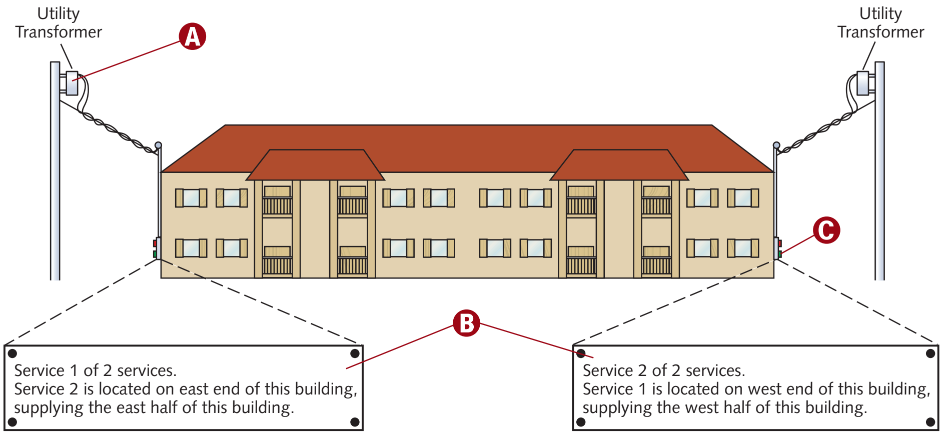
Ⓒ Six is the maximum number of service disconnects for any one location »*230.71(B)*«.

Note

One set of service-entrance conductors can supply the circuits of a two-family or multifamily dwelling as covered in 210.25 ***»230.40 Exception No. 4«***.

Warning

If separate services, feeders, or branch circuits supply a building and are required to be connected to a grounding electrode(s), the same grounding electrode(s) shall be used »*250.58*«.

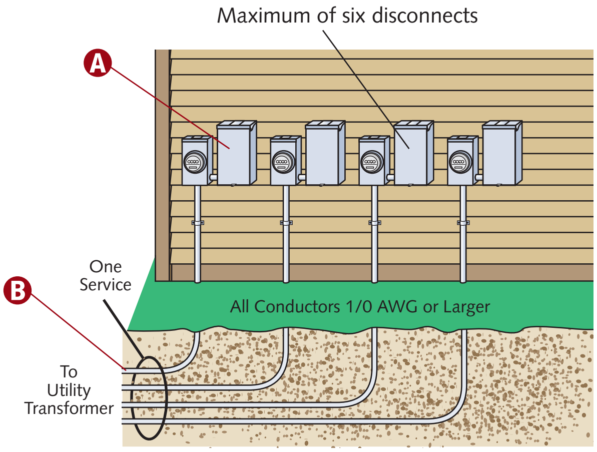

Utility Transformer
A
Utility Transformer
C
B
Service 1 of 2 services.
Service 2 is located on east end of this building, supplying the east half of this building.
Service 2 of 2 services.
Service 1 is located on west end of this building, supplying the west half of this building.

One Service Lateral—One Location

Service lateral is defined as the underground conductors between the utility electric supply system and the service point »*Article 100*«.

Ⓐ One set of service-entrance conductors can supply two to six service disconnecting means where located in separate enclosures, grouped at one location, and supply separate loads from one service drop or lateral. The one set of service-entrance conductors can supply each or several such service equipment enclosures »*230.40 Exception No. 2*«.

Ⓑ Only as applied to 230.40, Exception No. 2, underground sets of conductors, 1/0 AWG and larger, running to the same location and connected together at their supply end (but not at their load end) constitute one service »*230.2*«.


Maximum of six disconnects
A
B
One Service
All Conductors 1/0 AWG or Larger
To Utility Transformer

Note

Underground service conductors are defined as the underground conductors between the service point and the first point of connection to the service-entrance conductors in a terminal box, meter, or other enclosure, inside or outside the building wall ***»Article 100«***. Where there is no terminal box, meter, or other enclosure, the point of connection is considered to be the point of entrance of the service conductors into the building ***»Informational Note to the definition of Service Conductors, Underground«***.

One Service Lateral—Six Disconnects Maximum

A Six is the maximum number of disconnects per service *»230.71(B)«*.

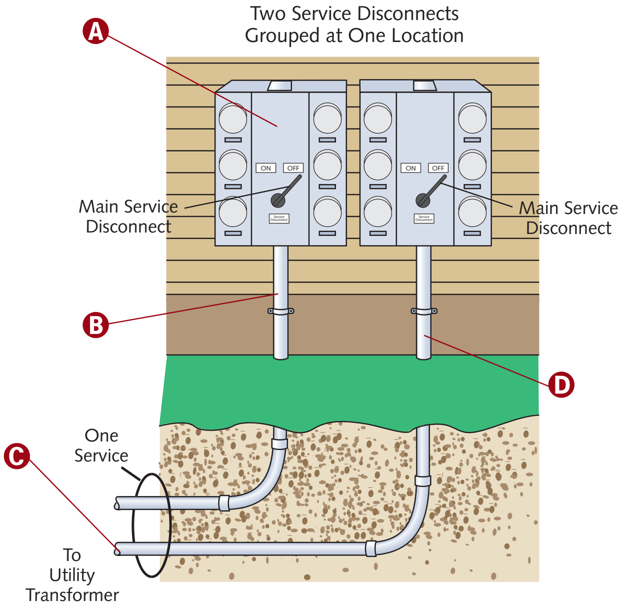
B Even though the service conductors are not connected to the same meter socket enclosure, this installation is defined as one service *»230.2«*.

C These are size 1/0 AWG and larger conductors running to the same location. Underground conductors are connected together at the supply (in the utility transformer).

D Underground service conductor provisions are found in 230.30 through 33.

Caution

Since the maximum number of disconnects is six, it is a violation to install two six-gang meter socket enclosures (each without a main service disconnect) for one service. (Two six-gang meter socket enclosures times six service disconnects each equals twelve disconnects.)



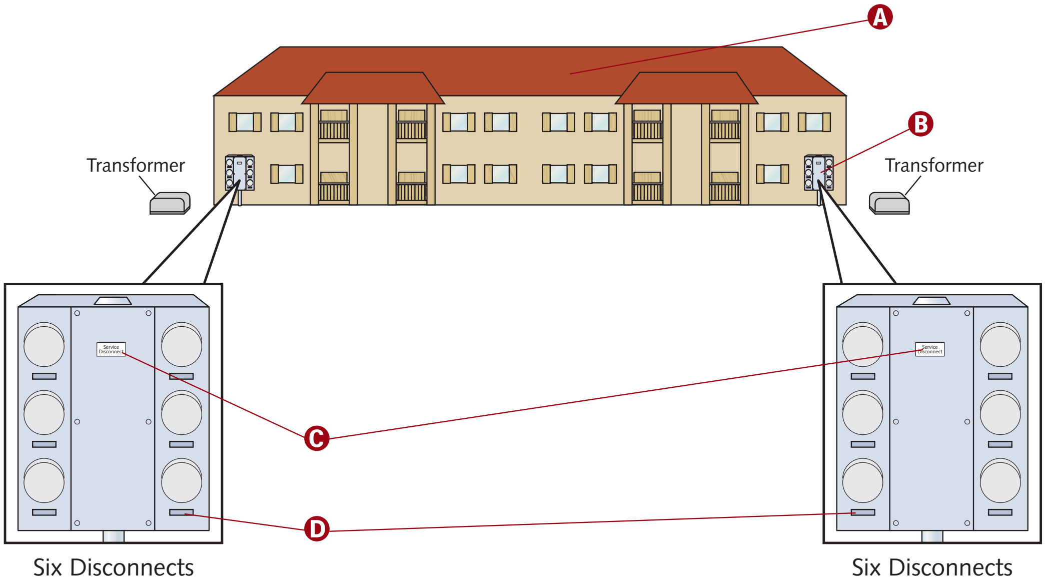
More Than Six Disconnects per Building

A Here, two services supply one building as permitted by 230.2(C)(2).

B The installation of two six-gang meter socket enclosures (each without a main service disconnect) in two locations is not a violation.

C Where a building or structure is supplied by multiple services, or by any combination of branch circuits, feeders, and services, a permanent plaque (or directory) must be installed at each service disconnect location denoting all other services, feeders, and branch circuits supplying that building, as well as the area served by each *»230.2(E)«*.

D Section 230.71(B) permits a maximum of six disconnects per service, not per building. If more than one service feeds a building, each service can have six disconnects.



Note

Each service must be connected to the same grounding electrode ***»250.58«***.

Caution

Service conductors supplying a building (or other structure) shall not pass through the interior of another building *»230.3«*.

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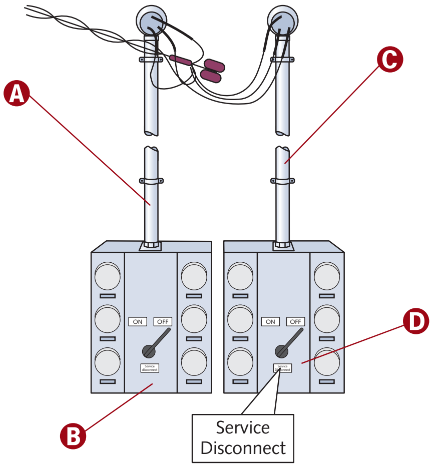
Service Conductors

Ⓐ If service entrance conductors are supplying power to more than one unit in a multifamily dwelling, using 310.12 and Table 310.12(A) is not permitted. In accordance with 310.12(A), selecting conductors from Table 310.12(A) shall be permitted where the service conductors supply the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling.

Ⓑ This book explains standard and optional multifamily load calculations in Unit 11.

Ⓒ If the calculated load to each service disconnect is 350 amperes, the conductor shall have an ampacity of at least 350 amperes. In accordance with Table 310.16, the minimum size conductor is 500 kcmil copper or 700 kcmil aluminum.

Ⓓ Two main service disconnecting means supplying power to twelve units must be computed on the basis of six units per service. Performing a service calculation on twelve units and then dividing by two is incorrect.



Caution

All services supplying dwelling units shall be provided with a surge-protective device (SPD). The SPD shall be an integral part of the service equipment or shall be located immediately adjacent thereto unless it is located at each next level distribution equipment downstream toward the load. The SPD shall be a Type 1 or Type 2 SPD. When replacing service equipment, all requirements 230.67 shall be met. SPDs shall have a nominal discharge current rating (In) of not less than 10 kA »*230.67(A) through (E)*«.

Service Wiring Clearances

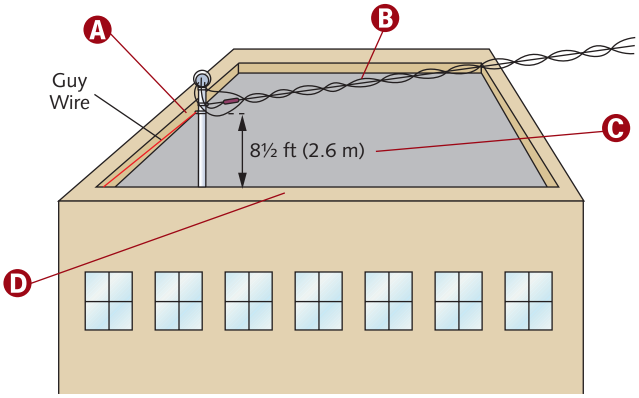
Conductor Clearance above Flat Roofs

Ⓐ The service mast shall be strong enough to safely withstand the strain imposed by the service drop or overhead service conductors. Supplemental braces or guys may be necessary »*230.28(A)*«.

Ⓑ Overhead service conductors shall not be readily accessible »*230.24*«.

Ⓒ Conductors must have a minimum vertical clearance of 8½ ft (2.6 m) above the roof surface »*230.24(A)*«.

Ⓓ The vertical clearance above roof level must be maintained for a distance of at least 3 ft (900 mm) from all edges of the roof »*230.24(A)*«.



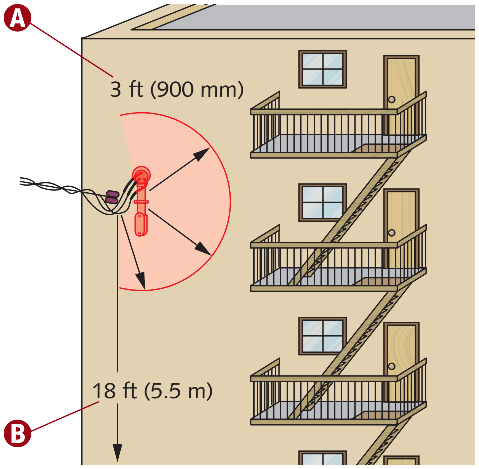
Note

Vertical clearances of overhead service conductors, covered in 230.24, pertain to every type of occupancy. Refer to Unit 9 (of this book) for detailed illustrations explaining vertical clearances.

Clearance from Openings

Ⓐ Open service conductors or multiconductor cable (having no overall outer jacket), must have a clearance of at least 3 ft (900 mm) from windows (designed to open), doors, porches, balconies, ladders, stairs, fire escapes, and similar locations »*230.9(A)*«.

Ⓑ Public streets, alleys, roads, parking areas subject to truck traffic, and nonresidential driveways require a minimum vertical clearance of 18 ft (5.5 m) »*230.24(B)(4)*«.



Note

Where buildings exceed three stories or 50 ft (15 m) in height, branch-circuit and feeder overhead lines must be arranged, where practicable, so that a clear area at least 6 ft (1.8 m) wide will be left adjacent to the buildings or beginning within 8 ft (2.5 m) to facilitate the raising of fire-fighting ladders »***225.19(E)***«.

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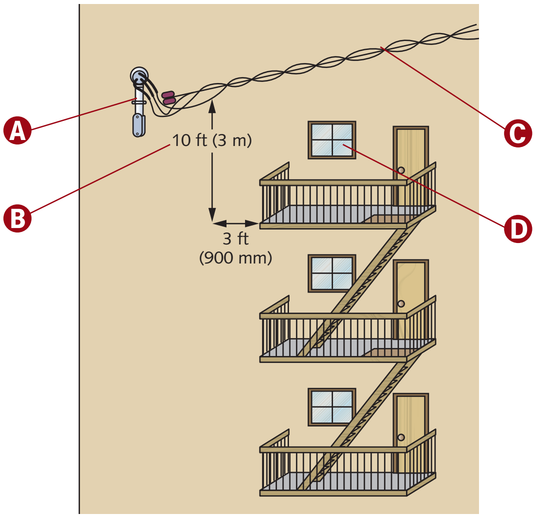
Vertical Clearance above Platforms

A A drip loop's lowest point has a minimum vertical clearance of 10 ft (3.0 m) »*230.24(B)(1)*«.

B Overhead service conductors accessible only to pedestrian traffic must have a minimum 10-ft (3.0-m) vertical clearance above final grade or other accessible surface from which they might be reached. The voltage shall not exceed 150 to ground »*230.24(B)(1)*«.

C Vertical clearance of final spans above or within 3 ft. (900 mm) measured horizontally of platforms, projections, or surfaces that will permit personal contact must be maintained in accordance with 230.24(B) »*230.9(B)*«.

D Here, the 3-ft (900-mm) clearance requirement does not apply to conductors run above the top level of a window »*230.9(A) Exception*«. Because of the fire escape platform, the 10-ft (3.0-m) vertical clearance takes precedence over the window clearance.



Panelboards and Equipment

Access to Overcurrent Devices

Where electric service and electrical maintenance are provided by building management and where these are under continuous building management supervision, service and feeder overcurrent protective devices supplying more than one occupancy can be accessible only to authorized management personnel in the following: (1) in multiple occupancy buildings and (2) for guest rooms or guest suites »*240.24(B)(1)*«.

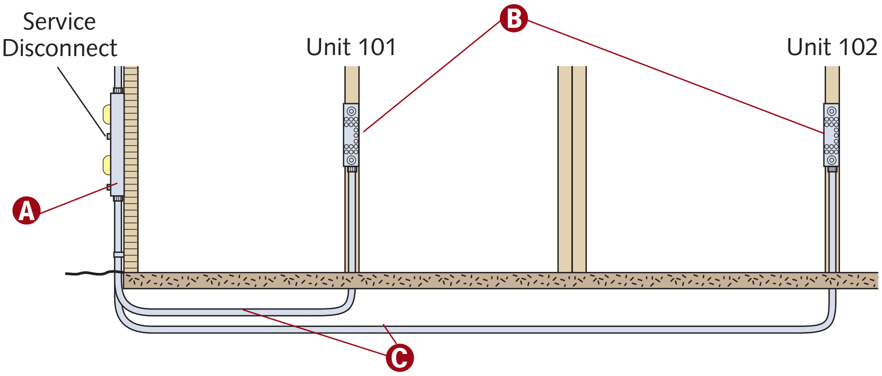
A In damp or wet locations, surface-type meter socket enclosures must be situated or equipped so as to prevent moisture from accumulating within the enclosure. There must be at least ¼-in. (6-mm) airspace between the enclosure and the wall »*312.2*«.

B Each occupant must have ready access to all overcurrent protective devices protecting the conductors supplying that occupancy unless otherwise permitted in 240.24(B)(1) and (B)(2) »*240.24(B)*«.

C It shall be permissible to use Table 310.12(A) to size 120/240-volt, single-phase individual dwelling unit services of two-family and multifamily dwellings and certain feeders rated 100 through 400 amps. »*310.12*«.

Note

Where the service overcurrent devices are locked, sealed, or otherwise not readily accessible to the occupant, branch-circuit or feeder overcurrent devices must be (1) installed on the load side of the service overcurrent device; (2) mounted in a readily accessible location; and (3) of lower ampere rating than the service overcurrent device »*230.92*«.



Caution

Overcurrent devices shall not be located in close proximity to easily ignitible material (such as in clothes closets) »*240.24(D)*«.

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Panelboards Supplying Individual Units

A Non-current-carrying metal parts of equipment, raceways, and other enclosures, if grounded, must be connected to an equipment grounding conductor by one of the following methods: (A) by any of the equipment grounding conductors permitted by 250.118(2) through (14), or (B) by an equipment grounding conductor contained within the same raceway or cable, or otherwise run with the circuit conductors »*250.134*«.

B Install the main bonding jumper (screw, strap, etc.) only in the service disconnecting means, not in subpanels.

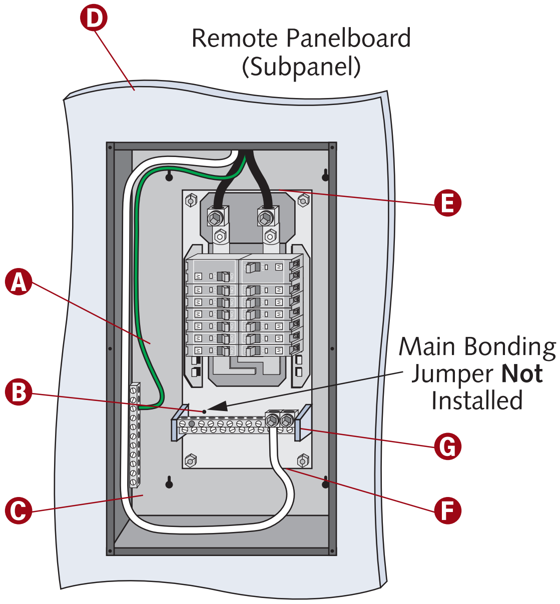
C At this point, the neutral bar is isolated from the equipment grounding system.

D The front edge of cabinets (panelboards) situated in walls constructed of noncombustible material (concrete, tile, etc.) must be within ¼ in. (6 mm) of, or extend beyond, the finished surface »*312.3*«.

E If all of the qualifications are met, Table 310.12(A) can be used to size feeder conductors.

F A grounded circuit conductor shall not be used for grounding non-current-carrying metal parts of equipment on the load side of the service disconnecting means, unless an exception has been met »*250.142(B)*«.

G A grounded conductor shall not be connected to normally non-current-carrying metal parts of equipment or to equipment grounding conductor(s) or be reconnected to ground on the load side of the service disconnecting means except as otherwise permitted in Article 250 »*250.24(A)(5)*«.


D
Remote Panelboard (Subpanel)
E
A
Main Bonding Jumper **Not** Installed
B
G
C
F

Warning

All switchboards and panelboards supplied by a feeder in other than one- or two-family dwellings shall be marked with the identification and physical location of where the power originates »*408.4(B)*«.

Caution

Cabinets in walls constructed of combustible material must be flush with or extend beyond the finished surface »*312.3*«.

Note

A circuit directory must be affixed to the face (or inside) of the panel door(s) indicating the clear and specific purpose of all circuits and any circuit modifications »***408.4(A)***«.

Note

Enclosures for overcurrent devices shall be mounted in a vertical position »***240.33***«.

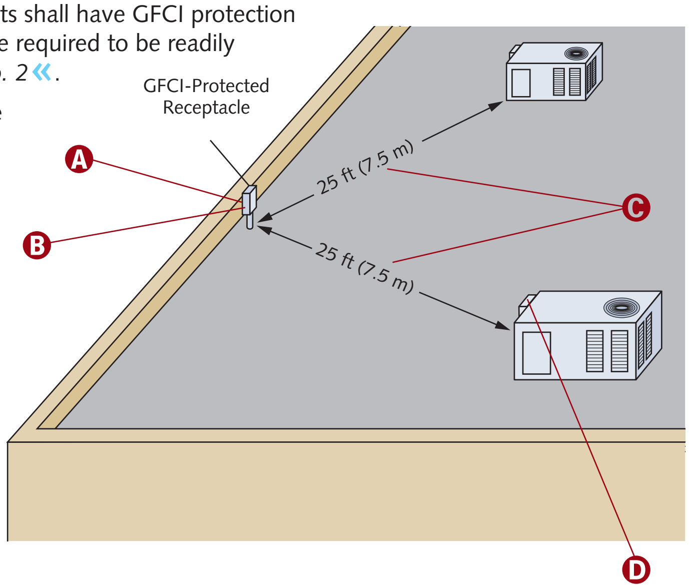
Rooftop Heating and Air-Conditioning Equipment

A All 125-volt through 250-volt receptacles supplied by single-phase branch circuits rated 150 volts or less to ground and located outdoors of dwelling units shall have GFCI protection »*210.8(A)(3)* and *(B)(6)*«. Receptacles on rooftops shall not be required to be readily accessible other than from the rooftop »*210.8(B) Exception No. 2*«.

B A 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet must be installed at an accessible location for the servicing of heating, air-conditioning, and refrigeration equipment »*210.63* and *210.63(A)*«.

C The receptacle must be located on the same level as, and within 25 ft (7.5 m) of the heating, air-conditioning, and refrigeration equipment »*210.63(A)*«. The provision does not stipulate that a receptacle must be located at every unit. One centrally located receptacle could meet the 210.63 requirement for all pieces of equipment located within the 25-ft (7.5-m) radius.

D Article 440 contains provisions pertaining to air-conditioning and refrigeration equipment.



Caution

The receptacle outlet shall not be connected to the load side of the equipment's branch-circuit disconnecting means »*210.63(A)*«.

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Feeder Conductors

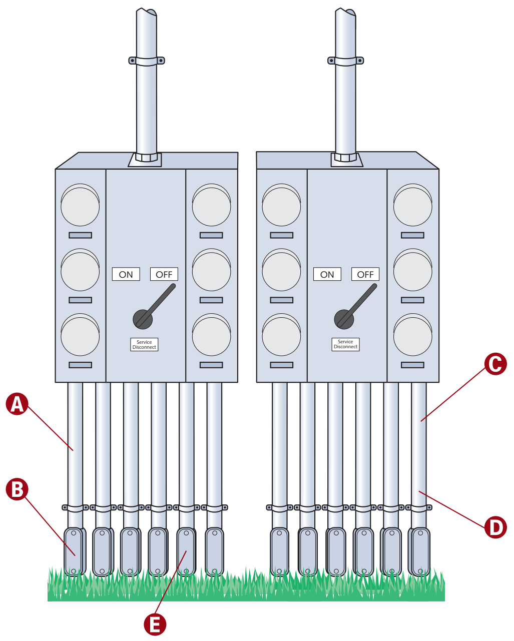
A For individual dwelling units of multifamily dwellings, feeder conductors supplied by a single-phase, 120/240-volt system shall be permitted to be sized in accordance with 310.12(A) through (D). For individual dwelling units of multifamily dwellings, single-phase feeder conductors consisting of two ungrounded conductors and the neutral conductor from a 208Y/120 volt system shall be permitted to be sized in accordance with 310.12(A) through (C). For a feeder rated 100 through 400 A, the feeder conductors supplying the entire load associated with an individual dwelling unit in a multifamily dwelling, shall be permitted to have an ampacity not less than 83% of the feeder rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied. »*310.12* and *310.12(B)*«.

B If each feeder is 100 amperes and the installation meets all the provisions in 310.12(B), it shall be permissible to select the conductor from Table 310.12(A). The minimum conductor size is 4 AWG copper or 2 AWG aluminum »*310.12(B)* and *Table 310.12(A)*«.

C Load calculations are computed for each individual unit having its own panelboard. Although located in a multifamily dwelling, each unit is calculated by one of the one-family methods. It is incorrect to perform a load calculation on multiple units and then divide by the number of units.

D Standard and optional one-family load calculations are explained in Unit 8 of this book.

E The AHJ may require a diagram showing feeder details prior to installation. Such a diagram must show the area in square feet of the building (or other structure) supplied by each feeder, the total calculated load before applying demand factors, the demand factors used, the calculated load after applying demand factors, and the size and type of conductors that will be used »*215.5*«.



Caution

On long runs, it may be necessary to increase the feeder conductors' size to compensate for voltage drop »*215.2(A)(2) Informational Note No. 2*«.

Branch Circuits

Receptacles

A For multifamily dwellings, each dwelling unit that is located at grade level and provided with individual exterior entrance/egress shall have at least one receptacle outlet readily accessible from grade and not more than 6½ ft (2.0 m) above grade level »*210.52(E)(2)*«.

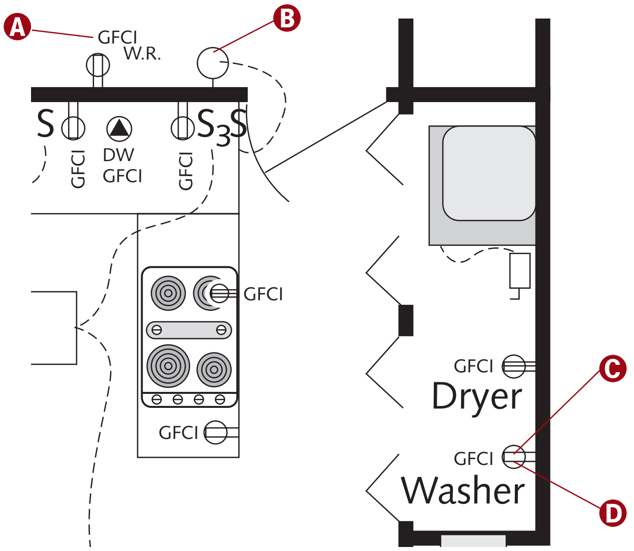
B Dwelling-unit branch circuits shall supply only loads within, or associated only with, that dwelling unit »*210.25(A)*«.

C A receptacle for laundry equipment shall not be required in a dwelling unit of a multifamily building where laundry facilities are provided on the premises for use by all building occupants »*210.52(F) Exception No. 1*«.

Note

Balconies, decks, and porches that are within 4 in. (102 mm) horizontally of the dwelling unit shall have at least one receptacle outlet accessible from the balcony, deck, or porch. The receptacle outlet shall not be located more than 6½ ft (2.0 m) above the balcony, deck, or porch walking surface ***»210.52(E)(3)«***. There is no exception for balconies, decks, and porches that have small usable areas.

D A receptacle for laundry equipment shall not be required in other than one-family dwellings where laundry facilities are not to be installed or permitted »*210.52(F) Exception No. 2*«.



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Receptacles *(continued)*

A The maximum distance to any receptacle, measured horizontally along the wall line, is 24 in. (600 mm) »*210.52(C)(1)*«.

B Dwelling-unit branch circuits shall supply only loads within, or associated only with, that dwelling unit »*210.25(A)*«.

C Receptacles must be installed so that no point measured horizontally along the floor line of any wall space is more than 6 ft (1.8 m) from a receptacle outlet »*210.52(A)(1)*«.

D *All 125-volt through 250-volt receptacles supplied by single-phase branch circuits rated 150 volts or less to ground* in kitchens must have GFCI protection »*210.8(A)(6)*«.

E All receptacles in kitchens require GFCI protection. There are no exceptions for receptacles serving appliances that are not easily moved.

F All receptacles in the kitchen, pantry, breakfast room, dining room, or similar areas must be supplied from 20-ampere small-appliance branch circuits (except for refrigeration equipment) »*210.52(B)(1)*«.

G Circuits feeding receptacles in kitchens, pantries, breakfast rooms, dining rooms, or similar areas shall not feed receptacles outside these areas »*210.52(B)(2)*«.

H GFCI protection is required for All 125-volt through 250-volt receptacles supplied by single-phase branch circuits rated 150 volts or less to ground located in bathrooms »*210.8(A)(1)*«.

I A receptacle is required for any wall space 2 ft (600 mm) or more in width (including space measured around corners), unbroken along the floor line by doorways and similar openings, fireplaces, and fixed cabinets »*210.52(A)(2)(1)*«.

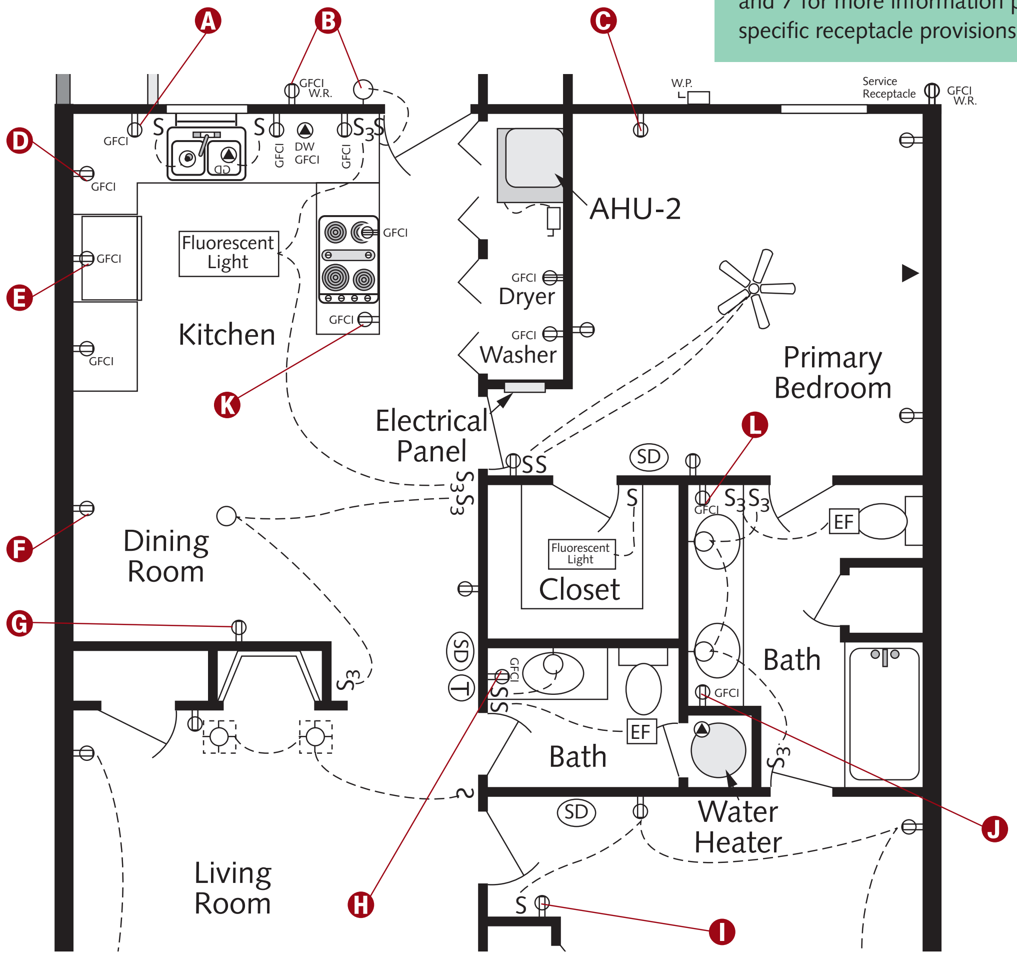
J Locate at least one receptacle within 36 in. (900 mm) of the outside edge of each sink. The receptacle outlet must be located on a wall or partition adjacent to the sink or sink countertop, located on the countertop, or installed on the side or face of the sink cabinet. In no case shall the receptacle be located more than 12 in. (300 mm) below the top of the sink or sink countertop. Receptacle outlet assemblies listed for the application shall be permitted to be installed in the countertop »*210.52(D)*«.

K Receptacle outlets, if installed to serve an island or peninsular countertop or work surface, shall be installed in accordance with 210.52(C)(3). If a receptacle outlet is not provided to serve an island or peninsular countertop or work surface, provisions shall be provided at the island or peninsula for future addition of a receptacle outlet to serve the island or peninsular countertop or work surface »*210.52(C)(2)*«.

L A circuit providing power to bathroom receptacles shall not provide power to any receptacles (or lighting) outside the bathroom, unless meeting an exception »*210.11(C)(3)*«.

Note

Only a few differences exist between one-family and multifamily dwelling receptacle requirements. Refer to Units 6 and 7 for more information pertaining to general as well as specific receptacle provisions.



Caution

In all areas in dwelling units, all nonlocking-type 125- and 250-volt, 15- and 20-ampere receptacles shall be listed tamper-resistant receptacles »*406.12(1)*«.

Warning

Arc-fault circuit-interrupter protection shall be provided for all 120-volt, single-phase, 10-, 15-, and 20-ampere branch circuits supplying outlets or devices installed in dwelling unit kitchens, family rooms, dining rooms, living rooms, parlors, libraries, dens, bedrooms, sunrooms, recreation rooms, closets, hallways, laundry areas, or similar rooms or areas by any of the means described in 210.12(A)(1) through (6). The arc-fault circuit interrupter shall be installed in a readily accessible location »*210.12* and *210.12(B)*«.

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General Lighting

A minimum of one wall switch–controlled lighting outlet is required for dwelling hallways »*210.70(A)(2)(1)*«.

A At least one wall switch–controlled lighting outlet must be installed in every habitable room, kitchen, laundry area, and bathroom of a dwelling »*210.70(A)(1)*«.

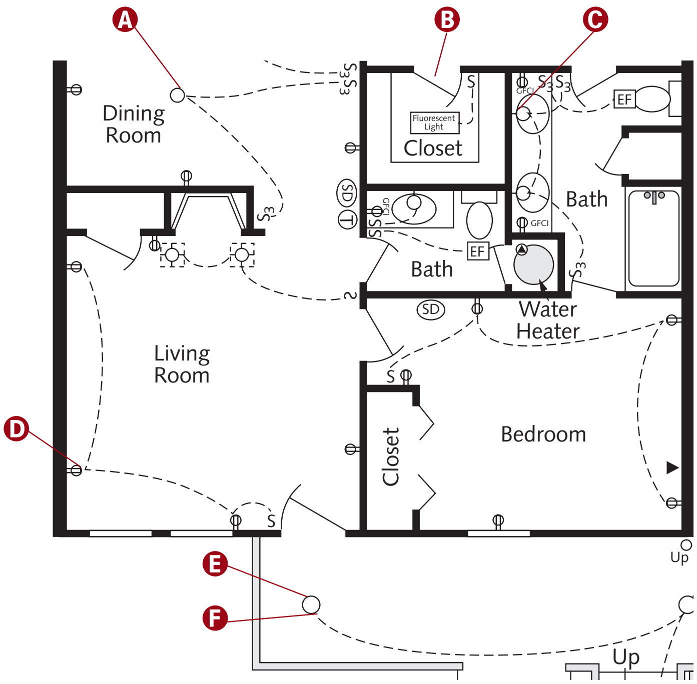
B Clothes closet lighting outlet provisions are found in 410.16.

C At least one wall switch–controlled lighting outlet must be installed in every dwelling bathroom »*210.70(A)(1)*«.

D Except for kitchens, laundry areas, and bathrooms, every habitable room is allowed one or more wall switch–controlled receptacle(s) in lieu of a lighting outlet »*210.70(A)(1) Exception No. 1*«.

E In hallways, stairways, and outdoor entrances, control of lighting can be remote, central, or automatic »*210.70(A)(2) Exception*«.

F Branch circuits installed for the purpose of lighting, central alarm, signal, communication, or other purposes for public or common areas of a two-family or multifamily dwelling shall not be provided from equipment that supplies an individual dwelling unit or tenant space »*210.25(B)*«.



Caution

The grounded circuit conductor for the controlled lighting circuit shall be installed at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit serving bathrooms, hallways, stairways, and habitable rooms or occupiable spaces as defined in the applicable building code. Where multiple switch locations control the same lighting load such that the entire floor area of the room or space is visible from the single or combined switch locations, the grounded circuit conductor shall only be required at one location. A grounded conductor shall not be required to be installed at lighting switch locations under any of the following conditions:

(1) Where conductors enter the box enclosing the switch through a raceway, provided that the raceway is large enough for all contained conductors, including a grounded conductor
(2) Where snap switches with integral enclosures comply with 300.15(E)
(3) Where lighting in the area is controlled by automatic means
(4) Where a switch controls a receptacle load »*404.2(C)*«.

Note

A listed box is required for a ceiling-suspended (paddle) fan where the box provides the only support »*314.27(C)*«.

Only a few differences exist between one-family and multifamily dwelling lighting requirements. Refer to Units 6 and 7 for more information pertaining to general as well as specific lighting provisions.

Appliance Disconnecting Means

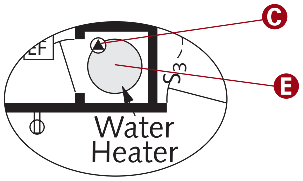
A A means must be provided to simultaneously disconnect each appliance from all ungrounded (hot) conductors from the appliance »*422.30*«.

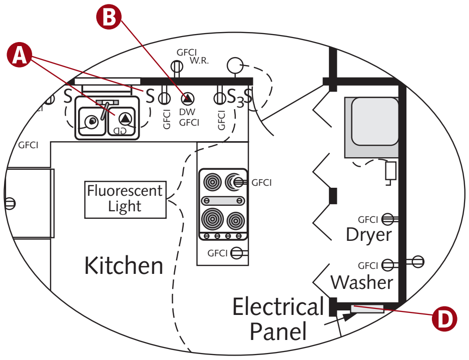
B An appliance switch marked with an "off" position that effectively disconnects all ungrounded conductors can serve as the disconnecting means required by Article 422 where other means for disconnection are provided in 422.34(A) through (D) »*422.34*«.

C For permanently connected appliances rated over 300 volt-amperes, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means where the switch or circuit breaker is within sight from the appliance or be capable of being locked in the open position in compliance with 110.25 »*422.31(B)*«.

D In multifamily dwellings, the other appliance disconnecting means (as described in 422.34) must be within the dwelling unit or on the same floor as the dwelling unit in which the appliance is installed and can also control lamps and other appliances »*422.34(A)*«.

E A The branch-circuit overcurrent device and conductors for fixed storage-type water heaters that have a capacity of 120 gal (450 L) or less shall be sized not smaller than 125% of the ampere rating of the water heater »*422.13*«.





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Heating and Air-Conditioning Equipment

A For a hermetic refrigerant motor compressor, the rated-load current marked on the equipment nameplate in which the motor compressor is employed must be used in determining the rating or ampacity of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground-fault protection, and the separate motor overload protection »*440.6(A)*«.

B The disconnecting means for air-conditioning or refrigerating equipment must be readily accessible and within sight of the equipment »*440.14*«.

C All electric equipment must be surrounded by sufficient unobstructed space to allow ready and safe equipment operation and maintenance »*110.26*«. Working space is mandatory for equipment likely to require examination, adjustment, servicing, or maintenance while energized »*110.26(A)*«.

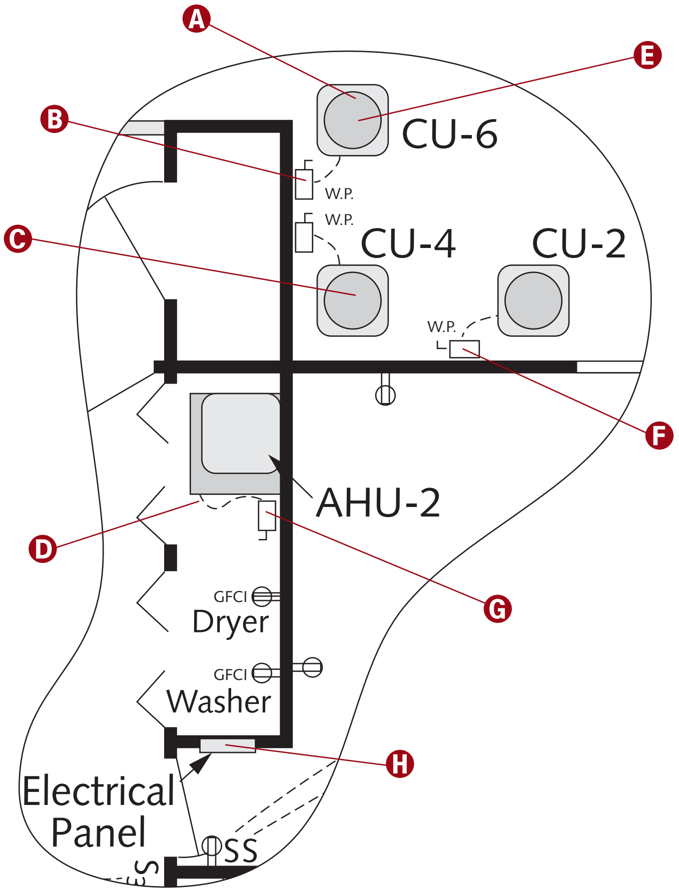
D Branch circuits for fixed electric space-heating equipment and associated motors shall be sized not smaller than 125% of the load »*424.4(B)*«.

E A hermetic refrigerant motor compressor is defined as a combination consisting of a compressor and motor, both of which are enclosed in the same housing, with no external shaft or shaft seals, with the motor operating in the refrigerant »*Article 100*«.

F On long runs, it may be necessary to increase the branch-circuit conductor's size to compensate for voltage drop »*210.19 Informational Note*«.

G Means shall be provided to simultaneously disconnect all ungrounded conductors from the heater, motor controller(s), and supplementary overcurrent protective device(s) of all fixed electric space-heating equipment »*424.19*«.

H In multifamily dwellings, the other disconnecting means, as described in 424.19(C), must be within the dwelling unit or on the same floor as the dwelling unit in which the fixed heater is installed and can also control general-purpose circuits and appliance circuits »*424.19(C)(1)*«.



Note

Fixed heater switch(es) marked with an "off" position that effectively disconnects all ungrounded conductors can serve as the disconnecting means required by Article 424, where other means for disconnection are provided in 424.19(C)(1) through (4) »*424.19(C)*«.

Caution

The disconnecting means shall be permitted to be installed on or within the air-conditioning or refrigerating equipment. The disconnecting means shall not be located on panels that are designed to allow access to the air-conditioning or refrigeration equipment or to obscure the equipment nameplate(s) »*440.14*«.

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Voltage Drop

Conductor Properties (Chapter 9, Tables 8 and 9)

While skin effect and induction change the resistance in alternating-current (ac) circuits, they do not affect direct-current (dc) circuits. The resistance of a conductor is slightly higher in an ac circuit. Table 9 contains the resistance of conductors in PVC, aluminum, and steel raceways. The factors that change resistance in an ac circuit, such as skin effect, are negligible in smaller conductors.

A The larger the circular mil area, the lower the resistance.

B As listed in Table 8, 6 AWG has an area of 26,240 circular mils.

C Size 3/0 AWG has an area of 167,800 circular mils and contains 19 strands.

D The abbreviated term "kcmil" stands for 1000 (k) circular (c) mills (mil).

E Each conductor size larger than 4/0 AWG is actually the circular mil size. A 250-kcmil conductor has a 250,000 circular mil area. A 500-kcmil conductor has a circular mil area of 500,000.

F Conductor overall diameter is listed in Table 8. This diameter is the actual wire and excludes conductor insulation.

G Conductor strand quantities are listed in Table 8; 6 AWG stranded conductor contains seven strands.

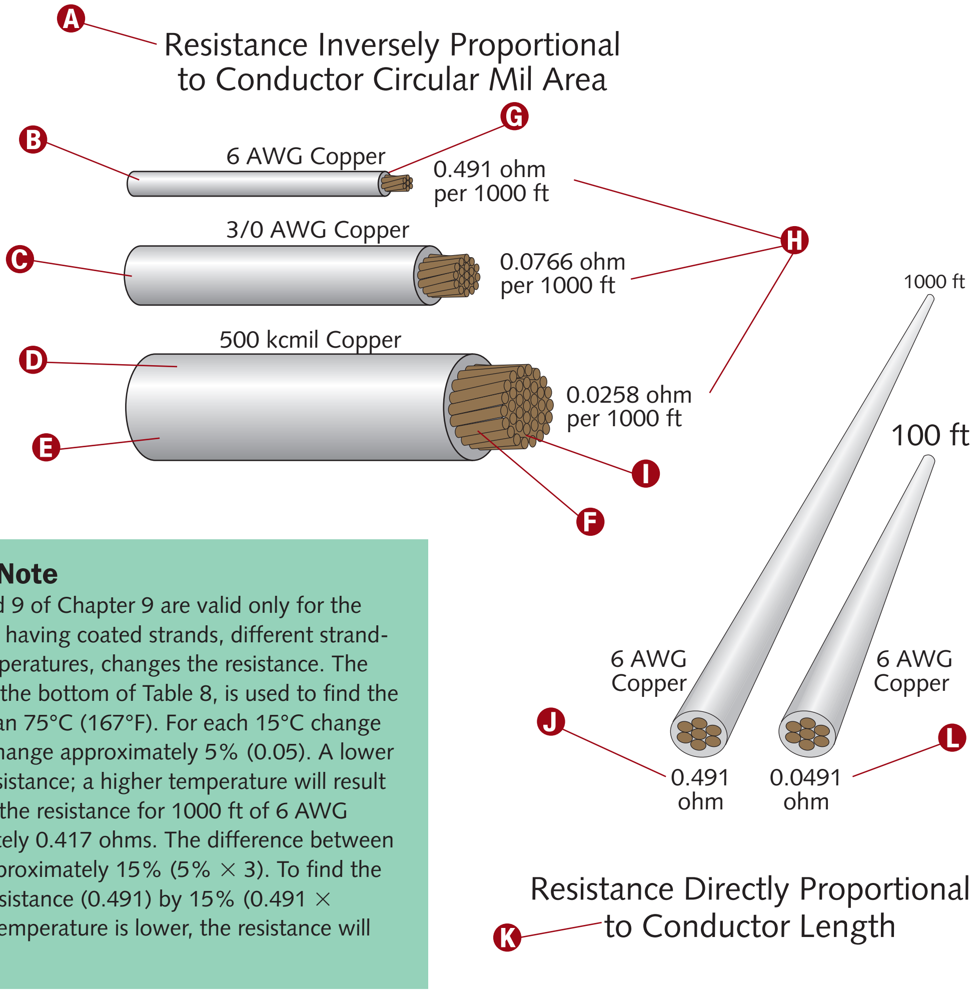
H Table 8 lists dc resistance values (in ohms per 1000 ft) at an ambient temperature of 75°C (167°F).

I Size 500-kcmil conductors have a quantity of 37 strands. The overall diameter is 0.813 in., with each strand having a diameter of 0.116 in.

J The dc resistance for 1000 ft of 6 AWG uncoated copper is 0.491 ohms.

K The longer the conductor, the higher the resistance.

L The dc resistance for 100 ft of 6 AWG uncoated copper is 0.0491 ohms (0.491 ÷ 1000 = 0.000491 × 100 = 0.0491).



Note

The resistance values in Tables 8 and 9 of Chapter 9 are valid only for the parameters given. Using conductors having coated strands, different stranding types, and, especially, other temperatures, changes the resistance. The formula for temperature change, at the bottom of Table 8, is used to find the resistance of conductors at other than 75°C (167°F). For each 15°C change in temperature, the resistance will change approximately 5% (0.05). A lower temperature will result in a lower resistance; a higher temperature will result in a higher resistance. For example, the resistance for 1000 ft of 6 AWG copper at 30°C (86°F) is approximately 0.417 ohms. The difference between 75°C and 30°C is 45°C, which is approximately 15% (5% × 3). To find the change in resistance, multiply the resistance (0.491) by 15% (0.491 × 15% = .07365 = .074). Since the temperature is lower, the resistance will be lower (0.491 − 0.074 = 0.417).

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Voltage-Drop Recommendation

A Except for sensitive electronic equipment in 647.4(D) and fire pumps in 695.7(A), voltage-drop considerations are only recommendations; compliance is optional.

B The recommended maximum voltage drop for the combined feeder and branch circuit is 5%. However, the recommended maximum voltage drop for both branch circuits and feeders is 3%. If the voltage drop on a branch circuit is 3%, the maximum recommended voltage drop for the feeder is 2%. If the voltage drop on a branch circuit is 1%, the maximum recommended voltage drop for the feeder is still only 3%.

C There is no recommended maximum voltage drop for service conductors.

D The conductor voltage that is dropped is a percentage of the source voltage.

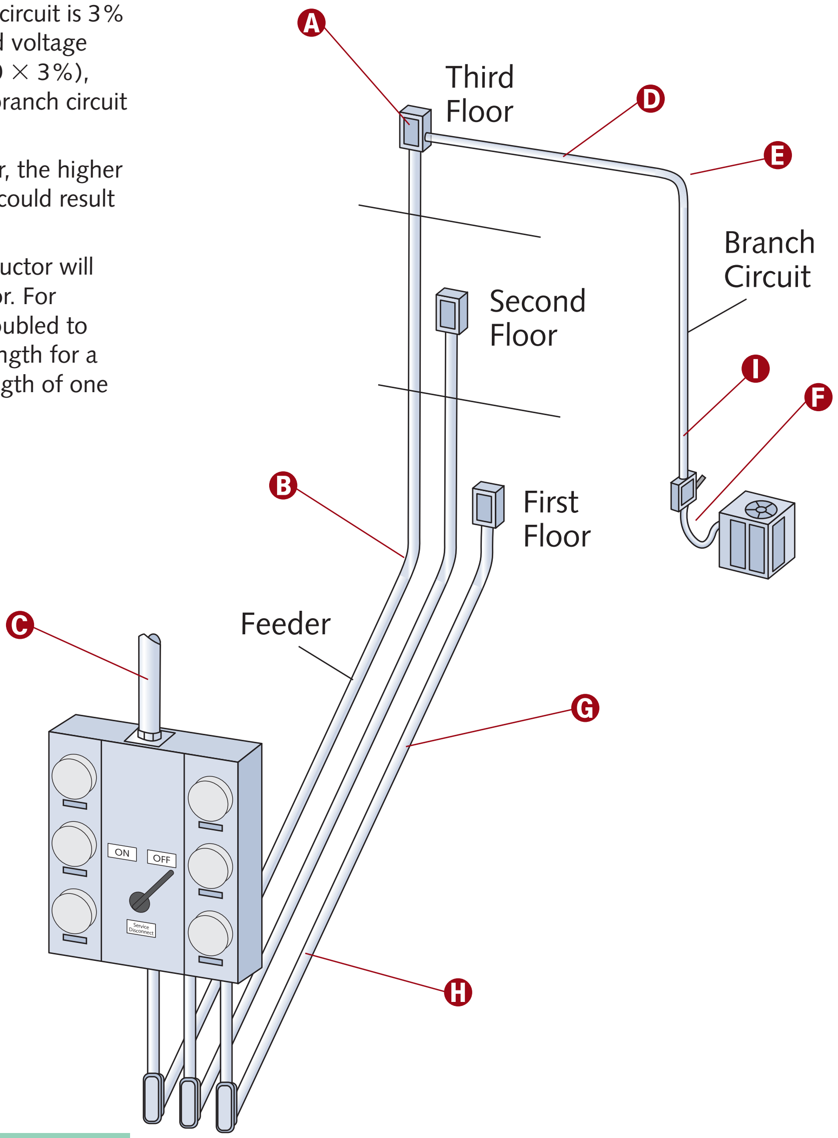
E The recommended voltage drop for a branch circuit is 3% or less. For example, the maximum recommended voltage drop for a 120-volt branch circuit is 3.6 volts (120 × 3%), and the maximum recommended for a 240-volt branch circuit is 7.2 volts (240 × 3%).

F The higher the resistance through a conductor, the higher the voltage drop. Such a conductor voltage drop could result in a reduction of voltage supplying the load.

G A single-phase feeder (or branch circuit) conductor will have a total resistance twice that of one conductor. For example, the length of one conductor must be doubled to find the total resistance of the circuit. The total length for a three-phase circuit is found by multiplying the length of one conductor by the square root of 3 (1.732).

H Conductors for feeders, as defined in Article 100, sized to prevent a voltage drop exceeding 3% at the farthest outlet of power, heating, and lighting loads (or combinations of such loads) and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5% will provide reasonable efficient operation »*215.2(A)(2) Informational Note No. 2*«.

I Conductors for branch circuits, as defined in Article 100, sized to prevent a voltage drop exceeding 3% at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5% will provide reasonable efficient operation »*210.19 Informational Note*«.



Note

Not all electrical installations have feeder conductors.

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Single-Phase Voltage-Drop Formulas

Formula Definitions:

V_D = Volts dropped from a circuit.

2 = Multiplying factor for single-phase (the 2 represents the total length of the circuit conductors in a single-phase circuit).

K = Resistivity of the conductor material. The resistance value (measured in ohms) is based on a mil foot at a given temperature. A mil foot is a piece of wire 1 ft long and one mil in diameter. Each conductor resistivity (K) factor can be found by multiplying the circular mil area (cmil) by the resistance (R) for 1 ft. For example, the K factor for a 6 AWG copper conductor at 75°C (167°F) is 12.88384, because 26,240 (area circular mills) × 0.000491 (ohms per ft) = 12.88384. At 75°C (167°F), the approximate K for copper is 12.9 and for aluminum is 21.2.

L = Length, *one way* only: The distance from the voltage source to the load.

I = Actual current used by the load. Do not use 125% for motors and continuous loads.

cmil = Circular mil area of the conductor (see Chapter 9, Table 8).

R = Conductor resistance for 1 ft. *Note:* The resistance values, listed in Chapter 9, Tables 8 and 9, are for 1000 ft. To find the resistance for 1 ft, simply divide the resistance by 1000. Example: The resistance for 1 ft of 6 AWG copper (at 75°C [167°F] is 0.000491 (0.491 ÷ 1000 = 0.000491).

Ⓐ This is one formula used to find voltage drop in a single-phase circuit.

Ⓑ The conductor voltage that is dropped is a percentage of the source voltage. To find the percentage, divide V_D by the source voltage. Example: 2.4 volts dropped from a 120-volt circuit is 2% of the source voltage (2.4 ÷ 120 = 0.02 = 2%).

Ⓒ Here is another formula for finding voltage drop in a single-phase circuit. This method uses the Ohm's law formula. Resistance (for 1 ft of the conductor) is used instead of the K factor and circular mil area.

Ⓓ Use this formula to find the maximum length (distance) from the source to the load. Because of the "2" in the formula, the length is **one way.**

Ⓔ This Ohm's law formula finds the maximum length from the source to the load without exceeding the voltage drop used in the formula.

Ⓕ Conductor size can be found using this formula. The calculation provides the minimum circular mil wire size that must be installed to remain below the V_D that was input into the formula.

Ⓖ This formula applies Ohm's law to find the conductor size. The result is the minimum conductor resistance for 1 ft; this keeps the voltage drop below the V_D used in the formula.

Ⓗ This formula calculates the maximum current in amperes.

Ⓘ Use this Ohm's law formula to find the current in amperes.

Ⓙ Since the conductor size is unknown, the exact K cannot be calculated. For copper, at 75°C (167°F), use **12.9** (approximate K). For aluminum, at 75°C (167°F), use **21.2** (approximate K).

Ⓚ V_D represents the actual volts that can drop from the circuit. The maximum (recommended) percentage for a branch circuit is 3%. Be careful not to place "3%" in the V_D position. If the voltage is 120, then 3.6 is the actual volts that can drop in the branch circuit. For 240 voltage, the actual volts that can drop in the branch circuit is 7.2.

Ⓐ Ⓑ
$$V_D = \frac{2 \times K \times L \times I}{\text{cmil}}$$

Ⓕ Ⓙ Ⓚ
$$\text{cmil} = \frac{2 \times K \times L \times I}{V_D}$$

Ⓒ
$$V_D = 2 \times R \times L \times I$$

Ⓖ
$$R = \frac{V_D}{2 \times L \times I}$$

Ⓓ
$$L = \frac{\text{cmil} \times V_D}{2 \times K \times I}$$

Ⓗ
$$I = \frac{\text{cmil} \times V_D}{2 \times K \times L}$$

Ⓔ
$$L = \frac{V_D}{2 \times R \times I}$$

Ⓘ
$$I = \frac{V_D}{2 \times R \times L}$$

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Three-Phase Voltage-Drop Formulas

Ⓐ The multiplying factor for three-phase is "1.732." The square root of 3 (1.732) represents the total length of the circuit conductors in a three-phase circuit. The only difference between the single-phase and three-phase formulas is that "1.732" has replaced "2."

Ⓑ These formulas are used to find voltage drop in a three-phase circuit.

Ⓒ Use these formulas to find the maximum length (distance) from the source to the load in a three-phase circuit. (Because of the "1.732" in the formula, the length is **one way.**)

Ⓓ These are variations of three-phase formulas.

Ⓔ This formula calculates the conductor size in a three-phase circuit.

Ⓕ This formula is used to determine the resistance of the conductor in a three-phase circuit.

Ⓖ The maximum current in amperes in a three-phase circuit is calculated using this formula.

Ⓗ The single-phase formula can be changed to a three-phase formula by placing "0.866" in the line containing the "2." The purpose of putting "0.866" in the same line as "2" is simple: $2 \times 0.866 = 1.732$.
(Refer to the definitions in the previous section—Single-Phase Voltage-Drop Formulas.)

Ⓐ

Ⓑ

$$V_D = \frac{1.732 \times K \times L \times I}{\text{cmil}}$$

$$V_D = 1.732 \times R \times L \times I$$

Ⓒ

$$L = \frac{\text{cmil} \times V_D}{1.732 \times K \times I}$$

$$L = \frac{V_D}{1.732 \times R \times I}$$

Ⓓ

Ⓗ

$$V_D = \frac{2 \times K \times L \times I \times 0.866}{\text{cmil}}$$

$$L = \frac{\text{cmil} \times V_D}{2 \times K \times I \times 0.866}$$

Ⓔ

$$\text{cmil} = \frac{1.732 \times K \times L \times I}{V_D}$$

Ⓕ

$$R = \frac{V_D}{1.732 \times L \times I}$$

Ⓖ

$$I = \frac{\text{cmil} \times V_D}{1.732 \times K \times L}$$

$$I = \frac{V_D}{1.732 \times R \times L}$$

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Single-Phase Voltage-Drop Example

At 75°C (167°F), what size conductors are required to feed a 2-horsepower, 230-volt, single-phase motor that is 150 ft from the source? (Do not exceed *NEC*® recommendations.)

Ⓐ Both the supply and load side of this equipment disconnecting means are branch-circuit conductors; therefore, the maximum recommended voltage drop is 3% of the source voltage.

Ⓑ Table 430.248 lists full-load current (in amperes) for single-phase ac motors.

Ⓒ This is the voltage drop formula used to find the minimum size conductor.

Ⓓ This is the approximate K for copper at 75°C (167°F).

Ⓔ This is the current in amperes for a 2-horsepower, 230-volt, single-phase motor »*Table 430.248*«.

Ⓕ This is the minimum circular mil area required. Notice that a 12 AWG conductor (6530 circular mils) is too small for this installation.

Ⓖ This is the minimum size conductor recommended for this installation.

Ⓗ This is the maximum amount of voltage drop on a 230-volt branch circuit that remains within the 3% recommendation (230 × 3% = 6.9).

Ⓘ This is an alternative formula equally effective in determining the minimum size conductor.

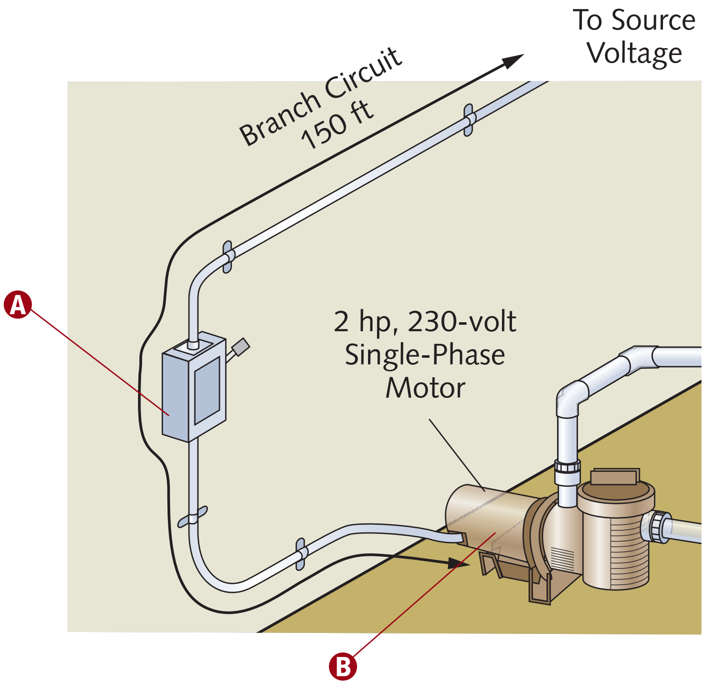
Ⓙ In multiplying the 1 ft value by 1000, the resistance values will correspond with Tables 8 and 9, which contain ohms per 1000 ft values.

Ⓚ This is the maximum conductor resistance for 1 ft.

Ⓛ The conductor chosen shall not exceed this resistance number. Both solid and stranded 12 AWG conductors have a higher resistance; therefore, 10 AWG conductors (solid or stranded) must be used.

Note

If the total distance of the branch circuit is less than 145 ft (44.2 m), a 12 AWG copper conductor could be installed.



$$\overset{C}{\text{cmil}} = \frac{2 \times K \times L \times I}{V_D} = \frac{2 \times \overset{D}{12.9} \times 150 \times \overset{E}{12}}{\underset{H}{6.9}} = \overset{F}{6730} = \overset{G}{\text{10 AWG copper}}$$

$$\overset{I}{R} = \frac{V_D}{2 \times L \times I} = \frac{6.9}{2 \times 150 \times 12} = \underset{K}{0.001917} \times \underset{J}{1000} = 1.917 = \underset{L}{\text{10 AWG copper}}$$

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Summary

- Overall receptacle installation requirements, with few exceptions, are the same for both one-family and multifamily dwellings.
- Outdoor receptacle requirements for multifamily dwellings are not the same as requirements for one-family dwellings.
- Under certain conditions, a laundry receptacle is not required.
- A multifamily clubhouse (or portion thereof) designed for the assembly of more than 99 persons must comply with Article 518 provisions.
- Generally, a building is supplied by only one service.
- There can be no more than six disconnects per service grouped in any single location.
- Where separate services supply a building and a grounding electrode is required, the same electrode must be used.
- Separate service laterals, grouped in one location, constitute one service.
- It is permissible to use Table 310.12(A) to size 120/240-volt, single-phase individual dwelling unit services of two-family and multifamily dwellings and certain feeders rated 100 through 400 amperes.
- It may be permissible to use Table 310.12(A) for single-phase feeder conductors supplied from a 208Y/120 volt system.
- Service and open conductor clearances pertain to all dwellings.
- Conductor properties are found in Chapter 9, Tables 8 and 9.
- Except for sensitive electronic equipment in 647.4(D) and fire pumps in 695.7(A), voltage-drop considerations are only recommendations.
- The recommended voltage drop for a branch circuit is 3% or less. The recommended voltage drop for a feeder is 3% or less.
- The recommended voltage drop for combined feeder and branch circuits is 5% or less.
- Voltage-drop formulas, complete with explanations, are found near the end of this unit.
- At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed in an accessible location within 25 ft (7.5 m) of the indoor electrical service equipment.

Unit 10 Competency Test

***NEC*® Reference** **Answer**

____________ ____________ 1. ____________ is a general term including material, fittings, devices, appliances, luminaires, apparatus, machinery, and the like used as a part of, or in connection with, an electrical installation.

____________ ____________ 2. Where a building is supplied by more than one service, or combination of branch circuits, feeders and services, a permanent ____________ or ____________ shall be installed at each service disconnect location denoting all other services, feeders, and branch circuits supplying that building and the area served by each.

____________ ____________ 3. Receptacle outlets installed to serve an island or peninsular countertop in a dwelling unit shall be installed on or above the countertop but not more than ____________ above the countertop.

____________ ____________ 4. A(n) ____________ is a device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply.

____________ ____________ 5. A(n) ____________ is a device intended to provide protection from the effects of arc faults by recognizing characteristics unique to arcing and by functioning to de-energize the circuit when an arc fault is detected.

____________ ____________ 6. Service-drop conductors shall have a vertical clearance of not less than ____________ ft above the roof surface.

____________ ____________ 7. What size copper equipment grounding conductor is required for a circuit having a 40-ampere overcurrent device?

____________ ____________ 8. A 125-ampere feeder will be installed to supply one unit of a multifamily dwelling. The feeder conductors for this panelboard are supplying the entire load associated with this individual dwelling unit. What minimum size copper feeder conductors are required?

NEC® Reference	Answer	
____________	____________	9. ____________ in each dwelling unit shall supply only loads within that dwelling unit or loads associated only with that dwelling unit.
____________	____________	10. Metal components that are installed in a run of underground installation of nonmetallic raceway(s) and are isolated from possible contact by a minimum cover of ____________ in. to all parts of the metal components shall not be required to be connected to the grounded conductor, supply-side bonding jumper, or grounding electrode conductor.
____________	____________	11. Service conductors shall be considered outside of a building or other structure where installed under not less than ____________ in. of concrete beneath a building or other structure.
____________	____________	12. What is minimum service demand load (in kW) for an apartment complex containing ten each of the following: 15-kW ranges, 13-kW ranges, 11-kW ranges, and 9-kW ranges? (The service is 120/240 single-phase.)
____________	____________	13. In ____________, remote, central, or automatic control of lighting shall be permitted.
____________	____________	14. Service conductors installed as open conductors shall have a clearance of not less than ____________ ft from fire escapes.
____________	____________	15. A grounded circuit conductor shall be permitted to be connected to non-current-carrying metal parts of equipment on the ____________ side of the ac service disconnecting means.
____________	____________	16. Each unit of a 30-unit apartment building has a 4.5-kW clothes dryer. What is the minimum calculated service load (in kW) for these clothes dryers? (The service is 120/240 single-phase.)
____________	____________	17. Generally, the maximum spacing allowed between receptacle outlets in a multifamily dwelling is ____________ ft.
____________	____________	18. Overcurrent protective devices shall not be located in the vicinity of ____________, such as in clothes closets.
____________	____________	19. Cabinets and cutout boxes shall have ____________ to accommodate all conductors installed in them without crowding.
____________	____________	20. Where conductors carrying alternating current are installed in ferrous metal enclosures or metal raceways, they shall be arranged so as to avoid heating the surrounding metal by ____________.
____________	____________	21. ____________ is the highest current at rated voltage that a device is identified to interrupt under standard test conditions.
____________	____________	22. Balconies, decks, and porches that are within ____________ in. horizontally of a dwelling unit shall have at least one receptacle outlet accessible from the balcony, deck, or porch.
____________	____________	23. Enclosures for overcurrent devices shall be mounted in a ____________ position.
____________	____________	24. A metal pole supporting a luminaire, 18 ft above grade, must have a handhole of at least ____________ in.
____________	____________	25. Where a building or structure is supplied by more than one service, or any combination of branch circuits, feeders, and services, a ____________ shall be installed at each service disconnect location denoting all other services, feeders, and branch circuits supplying that building or structure and the area served by each.
____________	____________	26. ____________ is a combination consisting of a compressor and motor, both of which are enclosed in the same housing, with no external shaft or shaft seals, with the motor operating in the refrigerant.

***NEC*® Reference** **Answer**

____________ ____________ 27. For permanently connected appliances rated over ____________ volt-amperes, the branch-circuit switch or circuit breaker shall be permitted to serve as the disconnecting means where the switch or circuit breaker is within sight from the appliance or be capable of being locked in the open position in compliance with 110.25.

____________ ____________ 28. In a multiple-occupancy building, ____________ must have access to the occupant's service disconnecting means, unless electric service and electrical maintenance are provided by continuous building management.

____________ ____________ 29. ____________ is the necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and their accessories, connected to the serving utility and intended to constitute the main control and disconnect of the serving utility.

____________ ____________ 30. No parts of cord-connected luminaires, chain-, cable-, or cord-suspended luminaires, lighting track, pendants, or ceiling-suspended (paddle) fans shall be located within a zone measured ____________ ft horizontally and ____________ ft vertically from the top of the bathtub rim or shower stall threshold.

____________ ____________ 31. What is the ac resistance of 500 ft of 1000 kcmil aluminum wire in a steel conduit containing three single conductors?

____________ ____________ 32. At 75°C (167°F), what size copper conductors are required (without exceeding *NEC* recommendations) to feed a $\frac{1}{4}$-horsepower, 115-volt, single-phase motor located 230 ft from the source?

____________ ____________ 33. Interior metal water piping that is electrically continuous with a metal underground water pipe electrode and is located not more than ____________ ft from the point of entrance to the building, as measured along the water piping, shall be permitted to extend the connection to a grounding electrode.

____________ ____________ 34. What is the minimum calculated neutral load (in kW) for twelve 8 kW ranges installed in apartment units?

____________ ____________ 35. What is the percentage of voltage dropped on a circuit using two 10 AWG THW copper, stranded, branch-circuit conductors, 120-ft long, supplying a 21-ampere, 240-volt load?

____________ ____________ 36. At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed in an accessible location within ____________ ft of the indoor electrical service equipment in a multifamily dwelling.

____________ ____________ 37. In a multifamily dwelling, what is the maximum number of service disconnecting means (for each service) that can be installed at any one location, if separate enclosures with a main service disconnecting means in each enclosure are used?

____________ ____________ 38. ____________ is the term for underground conductors between the utility electric supply system and the service point.

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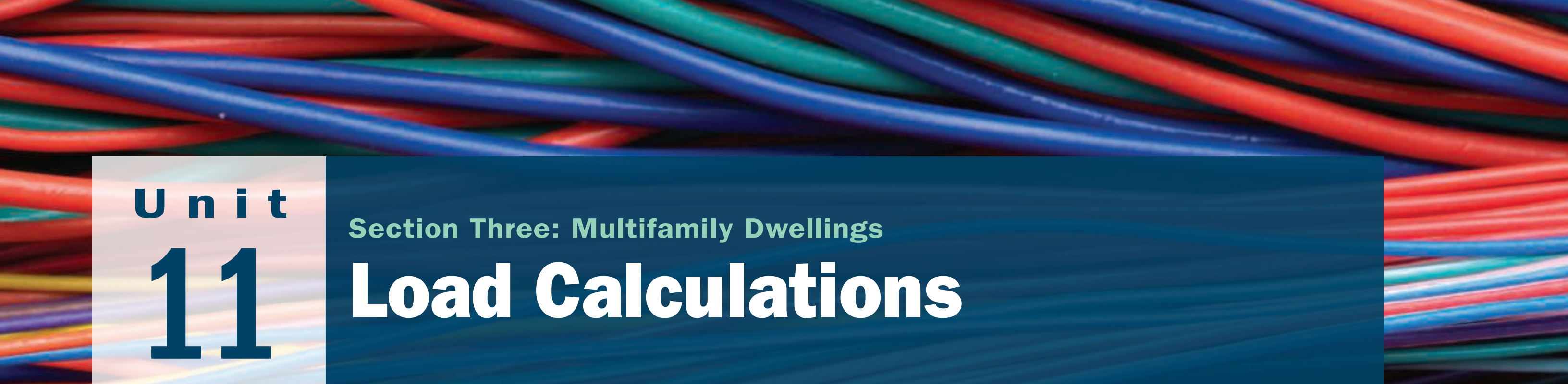


Unit 11

Section Three: Multifamily Dwellings

Load Calculations

Objectives

After studying this unit, the student should be able to:

- explain why the number of dwelling units is essential in performing a multifamily calculation.
- calculate the general lighting load in a multifamily dwelling.
- identify minimum volt-ampere requirements for small-appliance branch circuits.
- recall exceptions pertaining to optional laundry branch circuits.
- apply demand factors to the general lighting load, as well as to fastened-in-place appliances.
- calculate demand loads for household electric clothes dryers and household electric cooking equipment.
- explain the standard method for calculating a multifamily dwelling service.
- calculate a multifamily dwelling service using the optional method.
- calculate heating and air-conditioning loads to determine which load should be inserted into the calculation.
- summarize how to size service and feeder conductors.
- explain paralleled conductor provisions.
- calculate the neutral load and select the appropriate size neutral conductor.
- clarify how grounding electrode conductors, as well as equipment grounding conductors, are selected.

Introduction

Strong similarities exist between multifamily dwelling load calculations and one-family dwelling load calculations. Both can be performed by a standard method as well as an optional method. In fact, the similarities are so strong that this is reflected in the very design of the load calculation forms. It is, therefore, obviously beneficial to have a clear understanding of one-family dwelling load calculations before studying this unit (see Unit 8). It is absolutely essential to these calculations to know the total number of dwelling units being supplied by the service. To illustrate this point: Two main service disconnecting means supplying power to twelve units must be calculated on the basis of six units per service. Performing a service calculation on twelve units and then dividing the final figure by two would render inaccurate results.

The multifamily dwelling load calculations performed in this unit are based on the floor plan found in Unit 10. The statistical information for each individual dwelling unit remains unchanged for the purpose of load calculation. This data can be found in the floor plan diagram immediately following this introduction. Examples include a multifamily dwelling load calculation for both a twelve-unit and a six-unit service. Each will be calculated by the standard method as well as the optional. Feeder and panelboard sizing for individual units is demonstrated by a standard one-family dwelling calculation. For comparison, the optional method load calculation for one unit of a multifamily dwelling is shown after the optional multifamily dwelling computation.

Compiling Load Calculation Information

Load Calculation Information for Each Unit

A The smaller of two (or more) noncoincident loads can be omitted, as long as they are never energized simultaneously »*220.60*«.

B Although an electric clothes dryer is not a requirement for a load calculation, be sure to include a dryer load in units containing electric clothes dryer outlets.

C A laundry branch circuit is optional in multifamily dwellings »*210.52(F) Exception No. 1* and *2*«.

D Gather all load calculation information needed to calculate each service. For a service consisting of twelve units (apartment or condominium), compile the essential information for all twelve units. If the service consists of only six units, gather the data for those six units. Since most multifamily dwellings have a limited number of floor plans, compile the information pertaining to each "unit type" (style, floor plan, etc.). Be sure that each unit grouped in a unit type contains the same information, that is, total square feet, small-appliance branch circuits, laundry branch circuits, appliances, etc. For ease of demonstration in this section, each unit is identical in size and content.

E Calculate the floor area using the outside dimensions »*220.5(C)*«.

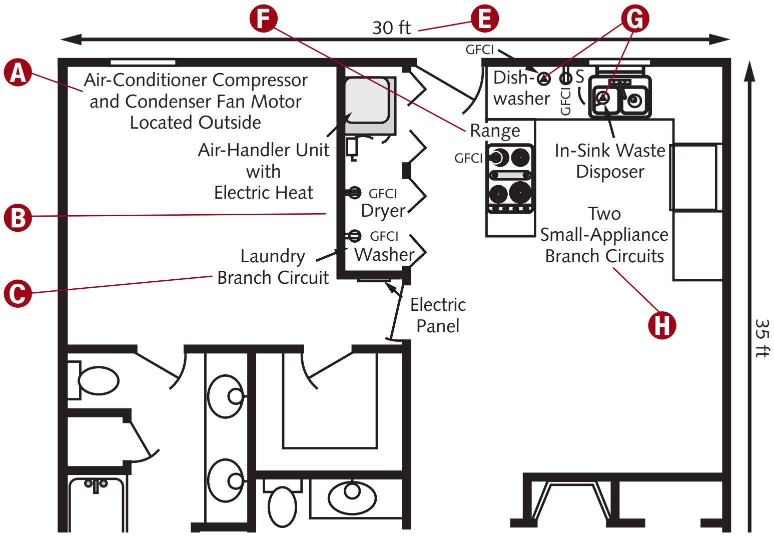
F Include household electric cooking appliances rated over 1¾ kW.

G Include all fastened-in-place appliances.

H Include at least two small-appliance branch circuits »*210.11(C)(1)*«.

Note

For this load calculation, the service is 120/240 volt, single-phase, 3-wire.



Dwelling outside dimensions	30′ × 35′
Small-appliance branch circuits	two
Laundry branch circuit	one
Electric water heater	4.5 kW, 240 volt
Dishwasher	10 amperes, 120 volt
Microwave oven	10 amperes, 120 volt
In-sink waste disposer	7.5 amperes, 120 volt
Electric clothes dryer	5 kW, 240 volt
Electric range	12 kW, 240 volt
Electric heat	5 kW, 240 volt
Air handler (blower motor)	3 amperes, 115 volt
Air-conditioner compressor	14 amperes, 230 volt
Condenser fan motor	2 amperes, 115 volt

Assume water heater, clothes dryer, range, and electric heat kW ratings equivalent to kVA.

Standard Method: Multifamily Dwellings

Load Calculation for Twelve Units

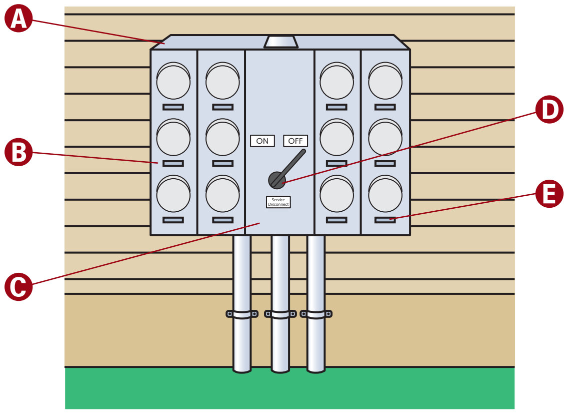
A The first multifamily load calculation form is based on twelve units. Each unit is identical, as previously described.

B In a multiple-occupancy building, each occupant must have access to the unit's service disconnecting means »*230.72(C)*«.

C There must not be more than six disconnects (switches or circuit breakers) per service »*230.71(B)*«.

D One service disconnecting switch controls all twelve units.

E Each unit's feeder (and overcurrent protection) must be calculated individually, using the one-family dwelling form (standard or optional method).



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Standard Method Load Calculation for Multifamily Dwellings

1 General Lighting and Receptacle Loads *220.41*
Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.
3 × ________ (sq ft outside dimensions) × ________ (number of units) = **1** ________

2 Small-Appliance Branch Circuits *220.52(A)*
At least ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*
1500 × ________ (minimum of two) × ________ (number of units) = **2** ________

3 Laundry Branch Circuit(s) *220.52(B)*
Include at least ***one*** *laundry branch circuit* *unless *meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*
1500 × ________ *(minimum of one) × ________ (number of units) = **3** ________

4 Add lines 1, 2, and 3 **4** ________

Lines 5 through 8 utilize the demand factors found in *Table 220.45.*

5 ________ (line 4) – 3000 = **5** ________ (if 117,000 or less, skip to line 8)

6 ________ (line 5, if more than 117,000) – 117,000 = **6** ________

7 ________ (line 6) × 25% = **7** ________

8 ________ (smaller of line 5 or 117,000) × 35% = **8** ________

9 Total General Lighting and Receptacle Load 3000 + ________ (line 7) + ________ (line 8) = **9** ________

10 Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or Greater *220.53*
Use the nameplate rating.
Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.

water heaters / ________ dishwashers / ________ disposers / ________
________ / ________ ________ / ________ ________ / ________
________ / ________ ________ / ________ ________ / ________

If fewer than four units, put total volt-amperes on line 10.
If four or more units, multiply total volt-amperes by 75%. ________ (volt-amps of four or more) × 75% = **10** ________

11 Electric Clothes Dryers *220.54*
(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.
The neutral demand load is 70% for services and feeders. *220.61(B)* **11** ________

12 Household Electric Cooking Appliances over 1750 Watts *220.55*
(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.
The neutral demand load is 70% for services and feeders. *220.61(B)* **12** ________

13 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60*
Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running. **13** ________

14 Largest Motor (one motor only) *220.50*, *440.32* through *440.35*, and *430.24* through *430.26*
Multiply the volt-amperes of the largest motor by 25%.
If 25% of the largest motor is in line 13, leave line 14 blank. ________ (volt-amps of largest motor) × 25% = **14** ________

15 Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.* **15** ________

16 Minimum Amperes
Divide the total volt-amperes by the voltage. ________ (line 15) ÷ ________ (voltage) = **16** ________ (minimum amperes)

17 **Minimum Size Service or Feeder** ***240.6(A)*** **17** ________

18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21*
Use the tables along with 310.15(A) through (F) to determine conductor size.
If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)
Minimum Size Conductors **18** ________

19 Size the Neutral Conductor. *220.61*
250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).
Minimum Size Neutral Conductor **19** ________

20 Size the Grounding Electrode Conductor (for Service). *250.66*
Use line 18 to find the grounding electrode conductor in Table 250.66.
Size the Equipment Grounding Conductor (for Feeder). *250.122*
Use line 17 to find the equipment grounding conductor in Table 250.122.
Equipment grounding conductor types are listed in 250.118.
Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor **20** ________

Line 1—General Lighting and Receptacle Loads

A Section 220.41 requires a minimum load of 3 volt-amperes per ft² (33 volt-amperes per m²) for the lighting and general use receptacle outlets in a dwelling unit.

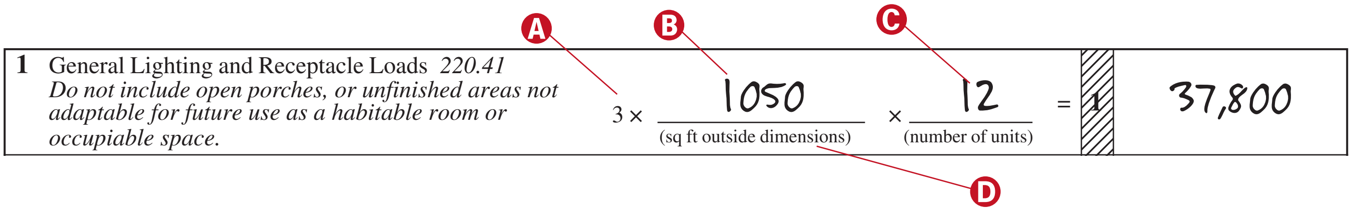
B Each multifamily dwelling unit has an outside dimension of 30 ft × 35 ft (1050 ft²).

C Insert the number of units (apartments or condominiums) that constitute one service. Additional space will be needed for computations if the units have different square footage dimensions.

D Each unit's floor area shall be calculated using the outside dimensions. The total floor area does not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space »*220.5(C)*«.

Note

All 15- or 20-ampere general-use receptacle outlets (except for small-appliance and laundry) are considered part of the general lighting load. No additional load calculations are required for these outlets »***220.41***«.



1 General Lighting and Receptacle Loads *220.41*
Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.
3 × 1050 (sq ft outside dimensions) × 12 (number of units) = 1 37,800

Line 2—Small-Appliance Branch Circuits

A Include small-appliance branch circuits when calculating a dwelling unit service »*220.52(A)*«.

B Each small-appliance branch circuit is calculated at no less than 1500 volt-amperes »*220.52(A)*«.

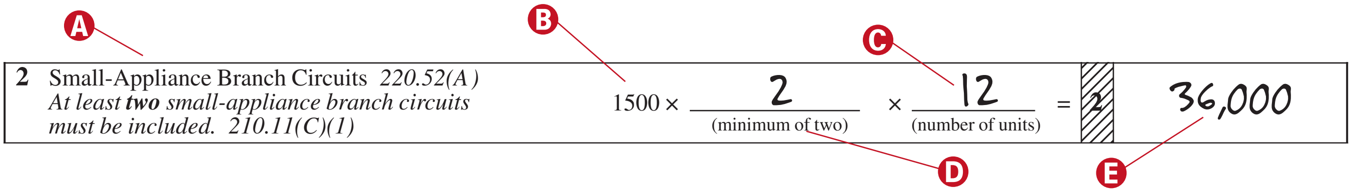
C If any unit(s) has a different number of small appliance branch circuits, calculate each separately.

D Each dwelling unit must have at least two small-appliance branch circuits »*210.11(C)(1)*«.

E These loads can be included with the general lighting load and are subject to Table 220.45 demand factors »*220.52(A)*«.

Note

A refrigeration equipment individual branch circuit (permitted by 210.52(B)(1) Exception No. 2) can be excluded from this calculation »***220.52(A) Exception***«.



2 Small-Appliance Branch Circuits *220.52(A)*
At least ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*
1500 × 2 (minimum of two) × 12 (number of units) = 2 36,000

Line 3—Laundry Branch Circuit(s)

A Include laundry branch circuit(s) when calculating a dwelling unit service »*220.52(B)*«.

B Each laundry branch circuit is calculated at no less than 1500 volt-amperes »*220.52(B)*«.

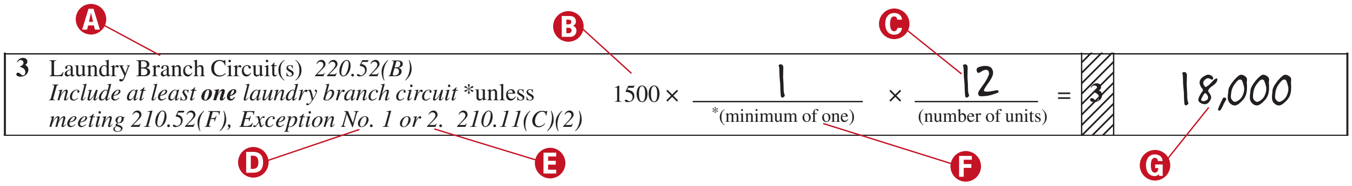
C Include only the number of units having a laundry branch circuit. If only six of twelve units contain a laundry branch circuit, put six as the number of units. In this calculation, each unit has a laundry branch circuit.

D A receptacle for laundry equipment shall not be required in a dwelling unit of a multifamily building where laundry facilities are provided on the premises for use by all building occupants »*210.52(F) Exception No. 1*«.

E A receptacle for laundry equipment shall not be required in other than one-family dwellings where laundry facilities are not to be installed or permitted »*210.52(F) Exception No. 2*«.

F Unless one of the exceptions is met, include at least one laundry branch circuit »*210.11(C)(2)*«.

G These loads can be included with the general lighting load and are subject to 220.45 demand factors »*220.52(B)*«.



3 Laundry Branch Circuit(s) *220.52(B)*
Include at least ***one*** *laundry branch circuit* *unless *meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*
1500 × 1 *(minimum of one) × 12 (number of units) = 3 18,000

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Lines 4 through 8—Applying Demand Factors Found in Table 220.45

Ⓐ Line 4 represents the total of lines 1, 2, and 3.

Ⓑ Lines 5 through 8 outline the derating procedure, using Table 220.45 demand factors.

Ⓒ Line 5 is the result of subtracting 3000 from the number in Line 4.

Ⓓ The first 3000 (or less) volt-amperes must remain at 100% »*Table 220.45*«.

Ⓔ If line 5 is 117,000 or less, skip lines 6 and 7.

Ⓕ If line 4 is 120,000 or less, then lines 6 and 7 remain empty.

Ⓖ Insert the smaller of line 5 or 117,000.

Ⓗ Multiply the next 117,000 (from 3001 to 120,000) by 35% »*Table 220.45*«.

4 Add lines 1, 2, and 3 Ⓐ	4	91,800	Ⓑ Lines 5 through 8 utilize the demand factors found in *Table 220.45.*		
5 91,800 Ⓒ (line 4) – 3000 = Ⓓ	5	88,800 Ⓔ (if 117,000 or less, skip to line 8)	6 ---- (line 5, if more than 117,000) – 117,000 =	6	---- Ⓕ
7 ---- (line 6) × 25% =	7	----	8 88,800 (smaller of line 5 or 117,000) Ⓖ × 35% = Ⓗ	8	31,080

Line 9—Total General Lighting (and Receptacle) Load

Ⓐ Line 9 is the total of general lighting, general-use receptacles, small-appliance branch circuits, and laundry branch circuit(s) after derating.

Ⓑ If line 7 is blank, leave this blank also.

Ⓒ Insert the result of line 8, not the number from line 5.

Ⓓ This shaded block draws attention to the first of six lines (boxes) that will be added together resulting in the total volt-ampere demand load for the one-family dwelling.

9 Total General Lighting and Receptacle Load Ⓐ	3000 +	Ⓑ ---- (line 7)	+	Ⓒ 31,080 (line 8)	= 9	Ⓓ 34,080

Line 10—Fastened-in-Place Appliances

Ⓐ The term **appliance** designates utilization equipment (commonly built in standardized types and sizes) installed as a unit to perform specific function(s) »*Article 100*«.

Ⓑ For the purpose of this load calculation, a kW rating is the same as a kVA rating.

Ⓒ Additional space may be needed to calculate total appliance volt-amperes; (1200 × 12 = 14,400) and (900 × 12 = 10,800).

Ⓓ Derating is allowed for a total of four (or more) fastened-in-place appliances. It is not necessary that the four fastened-in-place appliances be of different types. This derating factor can be used even if all units do not contain four appliances.

Ⓔ If the calculation contains at least four fastened-in-place appliances, the combined volt-ampere rating of those appliances is multiplied by 75% and placed on Line 10 »*220.53*«.

Note

Do not include household electric cooking equipment that is fastened in place, dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment as fastened-in-place appliances »*220.53*«. Household cooking appliances individually rated in excess of 1750 watts are derated under 220.55 provisions.

10 Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or Greater *220.53* Ⓐ *Use the nameplate rating.* *Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.*	Ⓑ water heaters / 54,000	Ⓒ dishwashers / 14,400	disposers / 10,800
	microwave ovens / 14,400	/	/
	/	/	/
Ⓓ If fewer than four units, put total volt-amperes on line 10. If four or more units, multiply total volt-amperes by 75%.	93,600 Ⓔ (volt-amps of four or more) × 75% =	10	70,200

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Line 11—Electric Clothes Dryers

Ⓐ A clothes dryer is not a requirement for a load calculation. Skip this line if there is no clothes dryer.

Ⓑ The electric dryer rating must be at least 5000 watts (volt-amperes) »*220.54*«.

Ⓒ Table 220.54 can be used to derate five (or more) electric clothes dryer loads. First, find the demand factor percentage across from the number of dryers. In this case the percentage is 46 (47 − 1 = 46%). Next, multiply the total dryer load by that percentage and put the result in line 11 (5000 × 12 = 60,000 × 46% = 27,600).

Ⓓ A clothes dryer neutral load on a service or feeder is calculated at 70% »*220.61(B)*«.

Ⓔ If the nameplate rating exceeds 5000 watts (volt-amperes), use the larger number »*220.54*«.

Note
For four (or fewer) clothes dryers, the demand is 100%.

Ⓐ Ⓑ Ⓒ

11 Electric Clothes Dryers *220.54*
(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.
The neutral demand load is 70% for services and feeders. *220.61(B)*
11 27,600

Ⓓ Ⓔ

Line 12—Household Electric Cooking Appliances

Ⓐ Household electric cooking appliances (ranges, wall-mounted ovens, counter-mounted cooking units, etc.) are not required in a load calculation. If no cooking appliances are rated over 1¾ kW, skip this line.

Ⓑ Individual household cooking appliances rated more than 1750 watts (volt-amperes) can be derated using Table 220.55 demand factors (and all applicable notes).

Ⓒ The demand for twelve 12 kW ranges comes from Table 220.55, Column C. First, look at the "Number of Appliances" column and find the number 12. Next, follow that row across to the last column (Column C) and find the kW demand load, which is 27. Finally, multiply this number by 1000 and place in line 12. Because each range is 12 kW, Columns A and B cannot be used.

Ⓓ For household electric ranges, wall-mounted ovens, and counter-mounted cooking units, the neutral load on a service or feeder is calculated at 70% »*220.61(B)*«.

Ⓐ Ⓑ Ⓒ

12 Household Electric Cooking Appliances over 1750 Watts *220.55*
(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.
The neutral demand load is 70% for services and feeders. *220.61(B)*
12 27,000

Ⓓ

Line 13—Heating or Air-Conditioning System

Ⓐ The smaller of two (or more) **noncoincident loads** can be omitted, as long as they are never energized simultaneously »*220.60*«. By definition, noncoincident means not occurring at the same time. A dwelling's electric heating system and air-conditioning system may be noncoincident loads.

Ⓑ The air handler (blower motor) has a rating of 345 volt-amperes (3 × 115 = 345). Because both loads are energized simultaneously, add the air handler to the 5 kW of electric heat.

Ⓒ Fixed electric space-heating loads are calculated at 100% of the total connected load »*220.51*«.

Ⓓ Because the air handler (blower) works with either the heating or the air conditioning, add it to both calculations.

Ⓔ Each unit contains an air-conditioner compressor (14 × 230 × 125% = 4025 VA), condenser fan motor (2 × 115 = 230 VA), and blower motor (3 × 115 = 345 VA). The combined load is 4600 volt-amperes. Because this is less than the heating load, omit the air-conditioner compressor and the condenser fan motor. Multiply each unit's heat load by the number of units (5345 × 12 = 64,140).

Note
A heat pump with supplementary heat is not considered a noncoincident load. Add the compressor full-load current to the maximum amount of heat that can be energized while the compressor is running. Remember to include all associated motor(s), that is, blower, condenser, etc.

Note
If a motor or air-conditioning load is part of the noncoincident load and is not the largest of the noncoincident loads, 125% of either the motor load or air-conditioning load, whichever is larger, shall be used in the calculation ***»220.60«***.

Ⓐ Ⓓ Ⓑ Ⓒ Ⓔ

13 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60*
Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.
13 64,140

Line 14—Largest Motor

A Multiply the largest motor in the dwelling calculation by 25% »*220.50*, *440.32* through *440.35*, and *430.24* through *430.26*«.

B This means a total of one motor, not one motor per unit.

C The largest motor is usually the air-conditioner compressor. If the air conditioner load has been omitted, use the second largest motor. In this case, use the 7.5-ampere in-sink waste disposer motor (7.5 × 120 = 900).

Note

If the largest motor is the air-conditioner compressor motor and it was not omitted, it is already in the calculation at 125%. When 25% of the largest motor is in line 13, leave line 14 blank or insert a zero.

A B C

14 Largest Motor (one motor only) *220.50*, *440.32* through *440.35*, and *430.24* through *430.26* *Multiply the volt-amperes of the largest motor by 25%.* *If 25% of the largest motor is in line 13, leave line 14 blank.*	900 (volt-amps of largest motor)	× 25% =	**14**	225

Line 15—Total Demand Load

A Find the minimum volt-ampere load by adding lines 9 through 14.

A

15 Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.*	**15**	223,245

Lines 16 and 17—Minimum Service or Feeder

A Place the total volt-ampere figure found in line 15 here.

B Write down the source voltage supplying the service equipment.

C Fractions of an ampere 0.5 and higher are rounded up to the nearest whole ampere, and fractions less than 0.5 are dropped »*220.5(B)*«.

D The service (or feeder) overcurrent protection must be higher than the number in line 16. A list of standard ampere ratings for fuses and circuit breakers is provided in Table 240.6(A).

E Divide the volt-amperes by the voltage to determine the amperage.

F This is the minimum amperage rating required for the service or feeder being calculated.

G The next standard size fuse or breaker above 930 amperes is 1000 »*Table 240.6(A)*«.

A B C D

16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	223,245 (line 15)	÷	240 (voltage)	=	**16**	930 (minimum amperes)	**Minimum Size 17 Service or Feeder** ***240.6(A)***	**17**	1000

E F G

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Line 18—Minimum Size Conductors

A Except for service and feeder conductors supplying the entire load associated with an individual dwelling unit in a multifamily dwelling, 310.12 and Table 310.12(A) cannot be used for sizing service and feeder conductors in multifamily dwellings »*310.12*«.

B Use Table 310.16 to find the minimum size conductors.

C When running **three** sets of paralleled copper conductors (for a 1000 ampere overcurrent device), the minimum size is 400 kcmil, unless the equipment is listed and identified for use with 90°C (194°F) conductors. Even if a 90°C (194°F) conductor (such as THHN) is installed, the ampacity rating shall not exceed the 75°C (167°F) ampacity, which is 335 »*110.14(C)*«. Because the overcurrent protection is rated over 800 amperes, the conductor ampacity must match (or exceed) the 1000 ampere rating (1000 ÷ 3 = 333.3 minimum amperes, each conductor) »*240.4(C)*«.

D Other parallel conductor combinations are possible, such as four sets of 250 kcmil copper (Cu), four sets of 350 kcmil aluminum (Al), five sets of 3/0 AWG Cu, five sets of 250 kcmil Al, etc. The smallest conductor that can be run in parallel is 1/0 AWG »*310.10(G)(1)*«.

E The number and type of paralleled conductor sets is a design consideration, not necessarily a *Code* issue. Exercise extreme care when designing a paralleled conductor installation, without violating provisions such as 110.14(A), 110.14(C), 240.4(C), 250.66, 250.122(F), 300.20(A), 310.10(G), etc.

F 1/0 AWG and larger conductors can be connected in parallel (electrically joined at both ends to form a single conductor) »*310.10(G)(1)*«.

Caution

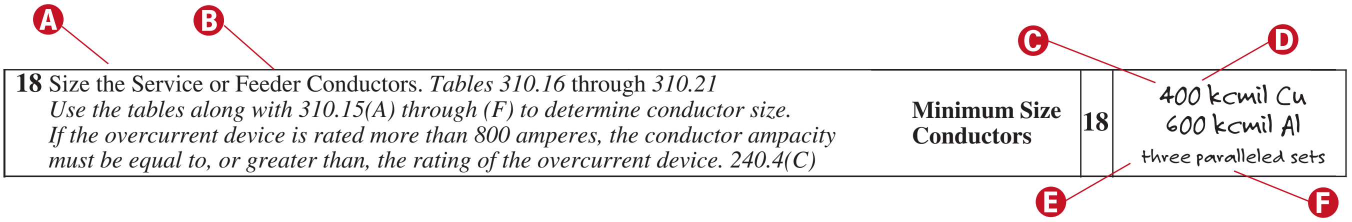
Conductors carrying alternating current and installed in ferrous metal enclosures or ***metal raceways*** must be arranged to avoid heating of the surrounding metal by induction »*300.20(A)*«.

Note

The paralleled conductors in each phase, polarity, neutral, grounded circuit conductor, equipment grounding conductor, or equipment bonding jumper must share the same characteristics »***310.10(G)(2)***«.

For example, all paralleled, Phase A conductors must:

(1) be the same length,
(2) consist of the same conductor material,
(3) be the same size in circular mil area,
(4) have the same insulation type, and
(5) be terminated in the same manner.



18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	**18**	400 kcmil Cu 600 kcmil Al three paralleled sets

Line 19—Neutral Conductor

A For the purpose of this load calculation, the terms **neutral** and **grounded conductor** are synonymous.

B The feeder (or service) neutral load is the maximum unbalance of the load determined by Article 220 »*220.61(A)*«.

C Size the neutral by finding the maximum unbalanced load.

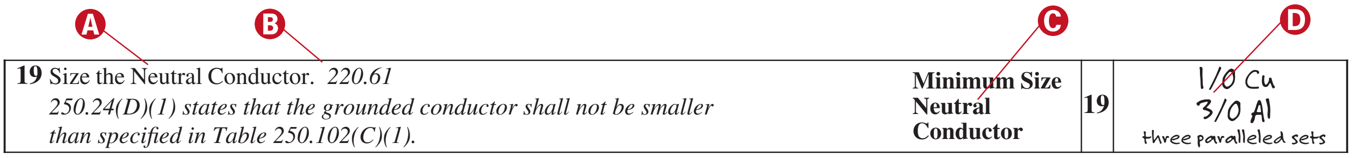
D Although the neutral conductor requires only 152 amperes each (for three paralleled sets), it shall not be smaller than required in Table 250.102 (C)(1).

Note

The smallest paralleled grounded (neutral) conductor is 1/0 AWG »***250.24(D)(2)***«.

Caution

The grounded conductor for the service must not be smaller than required in Table 250.102(C)(1) »*250.24(D)(1)*«.



19 Size the Neutral Conductor. *220.61* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	**19**	1/0 Cu 3/0 Al three paralleled sets

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Line 19—Neutral Conductor *(continued)*

Ⓐ No neutral conductor is connected to the water heaters in this calculation.

Ⓑ All fastened-in-place appliances using a grounded conductor must be included.

Ⓒ The electric heat and air-conditioner compressor are 240-volt loads (no neutral).

Ⓓ Because all of these motors can be energized simultaneously, thereby contributing to the neutral load, include them in the neutral calculation.

Ⓔ To convert to amperes, simply divide volt-amperes by voltage. Since the calculated neutral load is over 200 amperes and the electrical system is 3-wire, single-phase ac, the provisions in 220.61(B) and (B)(2) allow a 70% demand factor to be applied to the amount over 200 amperes.

Ⓕ The minimum conductor ampacity for three paralleled neutral conductors is 126 amperes. Although the minimum size copper conductor at 75°C (167°F) is 1 AWG, the neutral conductor cannot be smaller than required by Table 250.102(C)(1) and cannot be smaller than 1/0 AWG since the conductors are run in parallel.

Ⓖ All numbers are shown in volt-amperes.

Ⓗ Since all of the general lighting and receptacle loads have a rating of 120 volts, the total volt-ampere rating (from line 9) must be included in the neutral calculation.

Ⓘ A demand factor of 75% can be applied to the nameplate rating load of four (or more) fastened-in-place appliances »*220.53*«.

Ⓙ Multiply the electric clothes dryer load (line 11) by 70% to determine the neutral load »*220.61(B)*«.

Ⓚ Multiplying line 12 by 70% provides the electric cooking appliances neutral load »*220.61(B)*«.

Ⓛ Multiply the largest 120- (115-) volt motor (one motor only) by 25% and include in the calculation.

Ⓜ The minimum neutral load is 109,125 volt-amperes.

Ⓝ The feeder or service-neutral load is permitted to have a 70% demand factor applied where the maximum unbalanced load has been determined in accordance with Table 220.55 for ranges and 220.54 for dryers »*220.61(B)* and *(B)(1)*«.

For example:

The feeder or service-neutral load for a 12 kW range installed in a dwelling unit is 5.6 kW. The demand in Column C of Table 220.55 provides the maximum unbalanced load of 8 kW. 8 kW × 70% = 5.6 kW.

The feeder or service-neutral load for a 4500-watt clothes dryer installed in a dwelling unit is 3500 watts. 220.54 specifies that the minimum load for electric clothes dryers installed in dwelling units is 5000 watts. The demand factor for one electric clothes dryer on Table 220.54 is 100%. 5000 watts × 70% = 3500 watts.

Ⓖ **General lighting and receptacles (line 9)**	**34,080** Ⓗ
Fastened-in-place appliances	
Ⓐ **Water heaters**	**0**
Ⓑ **Dishwashers (1200 × 12)**	**14,400**
Ⓑ **Waste disposers (7.5 × 120 × 12)**	**10,800**
Ⓑ **Microwave ovens (1200 × 12)**	**14,400**
Total	**39,600**
Ⓘ **Total fastened-in-place appliances (39,600 × 75%)**	**29,700**
Clothes dryers (line 11 × 70%)	**19,320** Ⓙ
Ranges (line 12 × 70%)	**18,900** Ⓚ
Ⓒ **Electric heat**	**0**
Ⓒ **Air-conditioner compressors**	**0**
Ⓓ **Air handlers (3 × 115 × 12)**	**4140**
Ⓓ **Condenser fan motors (2 × 115 × 12)**	**2760**
Largest motor (900 × 25%)	**225** Ⓛ
TOTAL	**109,125** Ⓜ

Ⓔ
109,125 ÷ 240 = 454.7 = 455 amperes
455 − 200 = 255 amperes of neutral current in excess of 200 amperes
255 × 70% = 178.5 = 179 amperes calculated neutral load over 200 amperes
200 + 179 = 379 amperes minimum neutral ampacity
379 ÷ 3 = 126.3 = 126 minimum amperes per neutral conductor Ⓕ

Note

The feeder or service-neutral load is permitted to have an additional 70% demand factor applied to the portion of an unbalanced load in excess of 200 amperes where the feeder or service is supplied from a 3-wire dc or single-phase ac system; a 4-wire, 3-phase system; a 3-wire, 2-phase system; or a 5-wire, 2-phase system ***»220.61(B)* and *(B)(2)«***.

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Line 20—Grounding Electrode Conductor

Ⓐ Table 250.66 has two headings below the title - ungrounded conductor size and grounding electrode conductor size. Each heading contains two columns: one for copper and one for aluminum (or copper-clad aluminum). Because of the four columns, take extreme care in selecting the correct grounding electrode conductor.

Ⓑ The grounding electrode conductor is determined by the largest ungrounded conductor (or the equivalent area) if the ungrounded conductors are paralleled. The equivalent area for three parallel sets in this calculation is 1200 kcmil copper (3 × 400) *or* 1800 kcmil aluminum (3 × 600).

Ⓒ The minimum size grounding electrode conductor is 3/0 AWG copper (or 250 kcmil aluminum) »*Table 250.66*«.

Ⓐ Ⓑ

20 Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	**20**	3/0 Cu 250 kcmil Al

Ⓒ

The following page shows the completed standard method load calculation for a twelve-unit multifamily dwelling, having all units combined in a single service.

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Standard Method Load Calculation for Multifamily Dwellings

1 General Lighting and Receptacle Loads *220.41* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*	3 × 1050 (sq ft outside dimensions) × 12 (number of units) =	1	37,800
2 Small-Appliance Branch Circuits *220.52(A)* *At least **two** small-appliance branch circuits must be included. 210.11(C)(1)*	1500 × 2 (minimum of two) × 12 (number of units) =	2	36,000
3 Laundry Branch Circuit(s) *220.52(B)* *Include at least **one** laundry branch circuit* *unless *meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*	1500 × 1 *(minimum of one) × 12 (number of units) =	3	18,000
4 Add lines 1, 2, and 3		4	91,800
Lines 5 through 8 utilize the demand factors found in *Table 220.45*.			
5 91,800 (line 4) – 3000 =	(if 117,000 or less, skip to line 8)	5	88,800
6 ---- (line 5, if more than 117,000) – 117,000 =		6	----
7 ---- (line 6) × 25% =		7	----
8 88,800 (smaller of line 5 or 117,000) × 35% =		8	31,080
9 Total General Lighting and Receptacle Load	3000 + ---- (line 7) + 31,080 (line 8) =	9	34,080
10 Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or Greater *220.53* *Use the nameplate rating.* *Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.*	water heaters / 54,000 dishwashers / 14,400 disposers / 10,800 microwave ovens / 14,400		
If fewer than four units, put total volt-amperes on line 10. If four or more units, multiply total volt-amperes by 75%.	93,600 (volt-amps of four or more) × 75% =	10	70,200
11 Electric Clothes Dryers *220.54* *(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.* The neutral demand load is 70% for services and feeders. *220.61(B)*		11	27,600
12 Household Electric Cooking Appliances over 1750 Watts *220.55* *(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.* The neutral demand load is 70% for services and feeders. *220.61(B)*		12	27,000
13 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60* *Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*		13	64,140
14 Largest Motor (one motor only) *220.50*, *440.32* through *440.35*, and *430.24* through *430.26* *Multiply the volt-amperes of the largest motor by 25%.* *If 25% of the largest motor is in line 13, leave line 14 blank.*	900 (volt-amps of largest motor) × 25% =	14	225
15 Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.*		15	223,245
16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	223,245 (line 15) ÷ 240 (voltage) =	16	930 (minimum amperes)
17 **Minimum Size Service or Feeder** ***240.6(A)***		17	1000
18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	18	400 kcmil Cu 600 kcmil Al three paralleled sets
19 Size the Neutral Conductor. *220.61* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	19	1/0 Cu 3/0 Al three paralleled sets
20 Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	20	3/0 Cu 250 kcmil Al

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Six-Unit Multifamily Dwelling Calculation

Two Meter Centers, Each Supplying Six Units

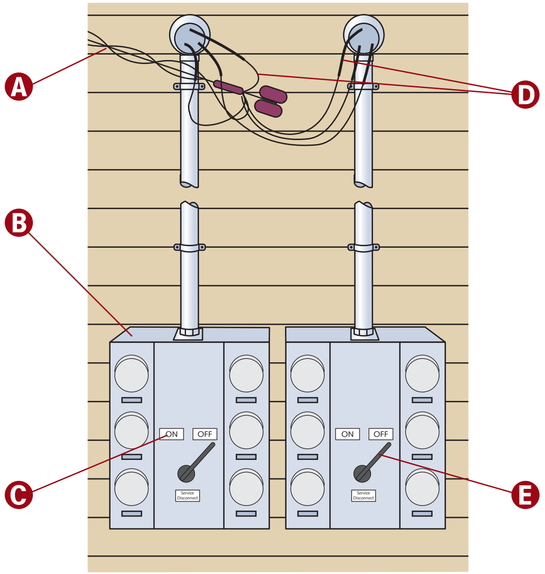
A Each service drop, set of overhead service conductors, set of underground service conductors, or service lateral supplies only one set of service-entrance conductors, unless two to six service disconnecting means (in separate enclosures) are grouped at one location and supply separate loads from one service drop »*230.40 Exception No. 2*«.

B Because service equipment installations can vary greatly, the arrangement must be known before a load calculation is performed. In this configuration, each service (conductors and equipment) must be able to carry the calculated load for six dwelling units.

C The following multifamily dwelling, standard method, load calculation is based on six units with identical configurations. Turn to page 245 for dwelling unit details.

D Service-entrance conductors must be able to carry the ampacity determined in accordance with Article 220 and shall have an ampacity of not less than the maximum load to be served »*230.42(A)*«.

E No more than six disconnects per service »*230.71(B)*«.



Lines 1 through 9—General Lighting and Receptacle Load

A Fill in the first three lines using six dwelling units instead of twelve.

B Insert the result of line 8, not the number from line 5.

C The general lighting and receptacle load for these six dwelling units is 18,015 volt-amperes. Compare this line 9 with the line 9 for twelve units (34,080). Obviously, this is not half of line 9 for twelve units; therefore, a calculation must be performed for each different application.

D Multiply the result of line 5 by 35% and place on line 8.

A

1	General Lighting and Receptacle Loads *220.41* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*				3 × 1050 (sq ft outside dimensions) × 6 (number of units) =	1	18,900
2	Small-Appliance Branch Circuits *220.52(A)* *At least* ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*				1500 × 2 (minimum of two) × 6 (number of units) =	2	18,000
3	Laundry Branch Circuit(s) *220.52(B)* *Include at least* ***one*** *laundry branch circuit* *unless *meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*				1500 × 1 *(minimum of one) × 6 (number of units) =	3	9000
4	Add lines 1, 2, and 3	**4**	45,900		Lines 5 through 8 utilize the demand factors found in *Table 220.45.*		
5	45,900 (line 4) – 3000 =	**5**	42,900 (if 117,000 or less, skip to line 8)	**6**	---- (line 5, if more than 117,000) – 117,000 =	**6**	----
7	---- (line 6) × 25% =	**7**	----	**8**	42,900 (smaller of line 5 or 117,000) × 35% =	**8**	15,015
9	Total General Lighting and Receptacle Load				3000 + ---- (line 7) + 15,015 (line 8) =	**9**	18,015

B **C** **D**

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Line 10—Fastened-in-Place Appliances

Ⓐ The term **appliance** designates utilization equipment (commonly built in standardized types and sizes) installed as a unit to perform specific function(s) »*Article 100*«.

Ⓑ For the purpose of this load calculation, a kW rating is the same as a kVA rating.

Ⓒ Additional space may be needed to calculate total appliance volt-amperes; (1200 × 6 = 7200) and (900 × 6 = 5400).

Ⓓ Derating is allowed for a total of four (or more) fastened-in-place appliances. It is not necessary that the four fastened-in-place appliances be of different types. This derating factor can be used even if all units do not contain four appliances.

Ⓔ If the calculation contains at least four fastened-in-place appliances, the combined volt-ampere rating of those appliances is multiplied by 75% and placed on Line 10 »*220.53*«.

Note

Do not include household electric cooking equipment that is fastened in place, dryers, space-heating equipment, and air-conditioning equipment as fastened-in-place appliances »***220.53***«.

Household cooking appliances individually rated in excess of 1750 watts are derated under 220.55 provisions.

	Ⓐ	Ⓑ	Ⓒ
10 Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or Greater *220.53* *Use the nameplate rating.* *Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.*	water heaters / 27,000	dishwashers / 7200	disposers / 5400
	microwave ovens / 7200	/	/
	/	/	/
Ⓓ If fewer than four units, put total volt-amperes on line 10. If four or more units, multiply total volt-amperes by 75%.	Ⓔ 46,800 (volt-amps of four or more)	× 75% = **10**	35,100

Lines 11 and 12—Electric Clothes Dryers and Household Electric Cooking Appliances

Ⓐ Use Table 220.54 to derate five (or more) clothes dryer loads. First, find the demand factor percentage across from the number of dryers, in this case 75%. Next, multiply the total dryer load by that percentage and record the result on line 11 (5000 × 6 = 30,000 × 75% = 22,500).

Ⓑ The demand for six 12-kW ranges comes from Table 220.55, Column C. First, look at the "Number of Appliances" column and find the number 6. Next, follow that row across to Column C and find the kW demand load, which is 21. Finally, multiply this number by 1000 and place in line 12. Since each range is 12 kW, Columns A and B cannot be used.

11 Electric Clothes Dryers *220.54* *(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.* The neutral demand load is 70% for services and feeders. *220.61(B)*	**11**	Ⓐ 22,500
12 Household Electric Cooking Appliances over 1750 Watts *220.55* *(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.* The neutral demand load is 70% for services and feeders. *220.61(B)*	**12**	21,000 Ⓑ

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Line 13—Heating or Air-Conditioning System

Ⓐ The smaller of two (or more) **noncoincident loads** can be omitted, as long as they are never energized simultaneously »*220.60*«. By definition, noncoincident means not occurring at the same time. A dwelling's electric heating system and air-conditioning system may be noncoincident loads.

Ⓑ The air handler (blower motor) has a rating of 345 volt-amperes (3 × 115 = 345). Because both loads are energized simultaneously, add the air handler to the 5 kW of electric heat.

Ⓒ Fixed electric space-heating loads are calculated at 100% of the total connected load »*220.51*«.

Ⓓ Because the air handler (blower) works with either the heating or the air conditioning, add it to both calculations.

Ⓔ Each unit contains an air-conditioner compressor (14 × 230 × 125% = 4025 VA), condenser fan motor (2 × 115 = 230 VA), and blower motor (3 × 115 = 345 VA). The combined load is 4600 volt-amperes. Because this is less than the heating load, omit the air-conditioner compressor and the condenser fan motor. Multiply each unit's heat load by the number of units (5345 × 6 = 32,070).

Note

A heat pump with supplementary heat is not considered a noncoincident load. Add the compressor full-load current to the maximum amount of heat that can be energized while the compressor is running. Remember to include all associated motor(s), that is, blower, condenser, etc.

Note

If a motor or air-conditioning load is part of the noncoincident load and is not the largest of the noncoincident loads, 125% of either the motor load or air-conditioning load, whichever is larger, shall be used in the calculation »***220.60***«.

Ⓐ Ⓓ Ⓑ Ⓒ Ⓔ

13 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60* *Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*	**13**	32,070

Line 14—Largest Motor

Ⓐ Multiply the largest motor in the dwelling calculation by 25% »*220.50, 440.32* through *440.35,* and *430.24* through *430.26*«.

Ⓑ This means a total of one motor, not one motor per unit.

Ⓒ The largest motor is usually the air-conditioner compressor. If the air conditioner load has been omitted, use the second largest motor. In this case, use the 7.5-ampere in-sink waste disposer motor (7.5 × 120 = 900).

Note

If the largest motor is the air-conditioner compressor motor and it was not omitted, it is already in the calculation at 125%. When 25% of the largest motor is in line 13, leave line 14 blank or insert a zero.

Ⓐ Ⓑ Ⓒ

14 Largest Motor (one motor only) *220.50,* *440.32* through *440.35*, and *430.24* through *430.26* *Multiply the volt-amperes of the largest motor by 25%.* *If 25% of the largest motor is in line 13, leave line 14 blank.*	900 (volt-amps of largest motor) × 25% =	**14**	225

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Lines 15 through 17—Minimum Amperes

Ⓐ The minimum volt-ampere load for these six dwelling units is 128,910.

Ⓑ The service-entrance conductors and equipment must have a rating of at least 537 amperes.

Ⓒ The next standard size fuse or circuit breaker above 537 is 600 amperes »*Table 240.6(A)*«.

Ⓐ

15 Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.*	**15**	128,910

16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	128,910 (line 15)	÷	240 (voltage)	=	**16**	537 (minimum amperes)	**17 Minimum Size Service or Feeder *240.6(A)***	**17**	600

Ⓑ Ⓒ

Line 18—Minimum Size Conductors

Ⓐ At 75°C (167°F), the minimum size copper conductors for two parallel sets matching or exceeding 537 amperes are 300 kcmil. Because the overcurrent protection is less than 800 amperes, the conductor ampacity can be less than the 600-ampere rating. The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) shall be permitted to be used, provided all of the following three conditions are met: (1) the conductors being protected are not part of a branch circuit supplying more than one receptacle for cord- and plug-connected portable loads, (2) the ampacity of the conductors does not correspond with the standard ampere rating of a fuse or a circuit breaker without overload trip adjustments above its rating (but that shall be permitted to have other trip or rating adjustments), and (3) the next higher standard rating selected does not exceed 800 amperes »*240.4(B)*«. The combined rating of two 300-kcmil copper conductors is 570 amperes. Because the combined rating of 250-kcmil copper conductors is only 510 amperes, which is below the minimum required conductor ampacity of 531 amperes, 250-kcmil conductors are not permitted.

Ⓑ Other parallel conductor combinations are possible, such as three sets of 3/0 AWG Cu and three sets of 4/0 AWG Al.

Ⓐ

18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size. If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	**18**	300 kcmil Cu 400 kcmil Al two paralleled sets

Ⓑ

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Line 19—Neutral Conductor

A The minimum neutral load is 66,990 volt-amperes.

B The minimum conductor ampacity for each of the two paralleled neutral conductors is 128 amperes. At 75°C (167°F), the minimum size conductor is 1/0 AWG copper *or* 2/0 AWG aluminum.

Note

Even with a lower neutral ampacity, the conductors must remain this size because the neutral conductor shall not be smaller than specified in Table 250.102(C)(1) ***»250.24(D)(1)«***.

General lighting and receptacles (line 9)		**18,015**
Fastened-in-place appliances		
Water heaters	**0**	
Dishwashers (1200 × 6)	**7200**	
Waste disposers (7.5 × 120 × 6)	**5400**	
Microwave ovens (1200 × 6)	**7200**	
Total	**19,800**	
Total fastened-in-place appliances (19,800 × 75%)		**14,850**
Clothes dryers (line 11 × 70%)		**15,750**
Ranges (line 12 × 70%)		**14,700**
Electric heat		**0**
Air-conditioner compressors		**0**
Air handlers (3 × 115 × 6)		**2070**
Condenser fan motors (2 × 115 × 6)		**1380**
Largest motor (900 × 25%)		**225**
TOTAL		**66,990**

A

66,990 ÷ 240 = 279.13 = 279 amperes
279 − 200 = 79 amperes of neutral current in excess of 200 amperes
79 × 70% = 55.3 = 55 amperes calculated neutral load over 200 amperes
200 + 55 = 255 amperes minimum neutral ampacity
255 ÷ 2 = 127.5 = 128 minimum amperes per neutral conductor

B

19 Size the Neutral Conductor. *220.61* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	**19**	1/0 Cu 2/0 Al two paralleled sets

Line 20—Grounding Electrode Conductor

A The equivalent area for two parallel sets of service entrance conductors, in this calculation, is 600 kcmil copper (2 × 300) . . . or . . . 800 kcmil aluminum (2 × 400).

B The minimum size grounding electrode conductor is 1/0 AWG copper *or* 3/0 AWG aluminum **»** *Table 250.66* **«**.

A

20 Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	**20**	1/0 Cu 3/0 Al

B

The following page shows the completed standard method load calculation for a six-unit multifamily dwelling.

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Standard Method Load Calculation for Multifamily Dwellings

1	General Lighting and Receptacle Loads *220.41* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*	3 × 1050 (sq ft outside dimensions) × 6 (number of units) =	1	18,900
2	Small-Appliance Branch Circuits *220.52(A)* *At least **two** small-appliance branch circuits must be included. 210.11(C)(1)*	1500 × 2 (minimum of two) × 6 (number of units) =	2	18,000
3	Laundry Branch Circuit(s) *220.52(B)* *Include at least **one** laundry branch circuit* *unless *meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*	1500 × 1 *(minimum of one) × 6 (number of units) =	3	9000
4	Add lines 1, 2, and 3		4	45,900
	Lines 5 through 8 utilize the demand factors found in *Table 220.45.*			
5		45,900 (line 4) – 3000 =	5	42,900 (if 117,000 or less, skip to line 8)
6		---- (line 5, if more than 117,000) – 117,000 =	6	----
7		---- (line 6) × 25% =	7	----
8		42,900 (smaller of line 5 or 117,000) × 35% =	8	15,015
9	Total General Lighting and Receptacle Load	3000 + ---- (line 7) + 15,015 (line 8) =	9	18,015
10	Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or Greater *220.53* *Use the nameplate rating.* *Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.*	water heaters / 27,000 dishwashers / 7200 disposers / 5400 microwave ovens / 7200 / / / / /		
	If fewer than four units, put total volt-amperes on line 10. If four or more units, multiply total volt-amperes by 75%.	46,800 (volt-amps of four or more) × 75% =	10	35,100
11	Electric Clothes Dryers *220.54* *(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.* The neutral demand load is 70% for services and feeders. *220.61(B)*		11	22,500
12	Household Electric Cooking Appliances over 1750 Watts *220.55* *(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.* The neutral demand load is 70% for services and feeders. *220.61(B)*		12	21,000
13	Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60* *Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*		13	32,070
14	Largest Motor (one motor only) *220.50, 440.32* through *440.35*, and *430.24* through *430.26* *Multiply the volt-amperes of the largest motor by 25%.* *If 25% of the largest motor is in line 13, leave line 14 blank.*	900 (volt-amps of largest motor) × 25% =	14	225
15	Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.*		15	128,910
16	Minimum Amperes *Divide the total volt-amperes by the voltage.*	128,910 (line 15) ÷ 240 (voltage) =	16	537 (minimum amperes)
17	**Minimum Size Service or Feeder** ***240.6(A)***		17	600
18	Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	18	300 kcmil Cu 400 kcmil Al two paralleled sets
19	Size the Neutral Conductor. *220.61* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	19	1/0 Cu 2/0 Al two paralleled sets
20	Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	20	1/0 Cu 3/0 Al

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Standard Load Calculation for Each Unit of a Multifamily Dwelling

Calculating Feeders for Individual Dwelling Units

Ⓐ A load calculation on an individual unit in a multifamily dwelling must be calculated in accordance with one of the one-family dwelling load-calculation methods (standard or optional).

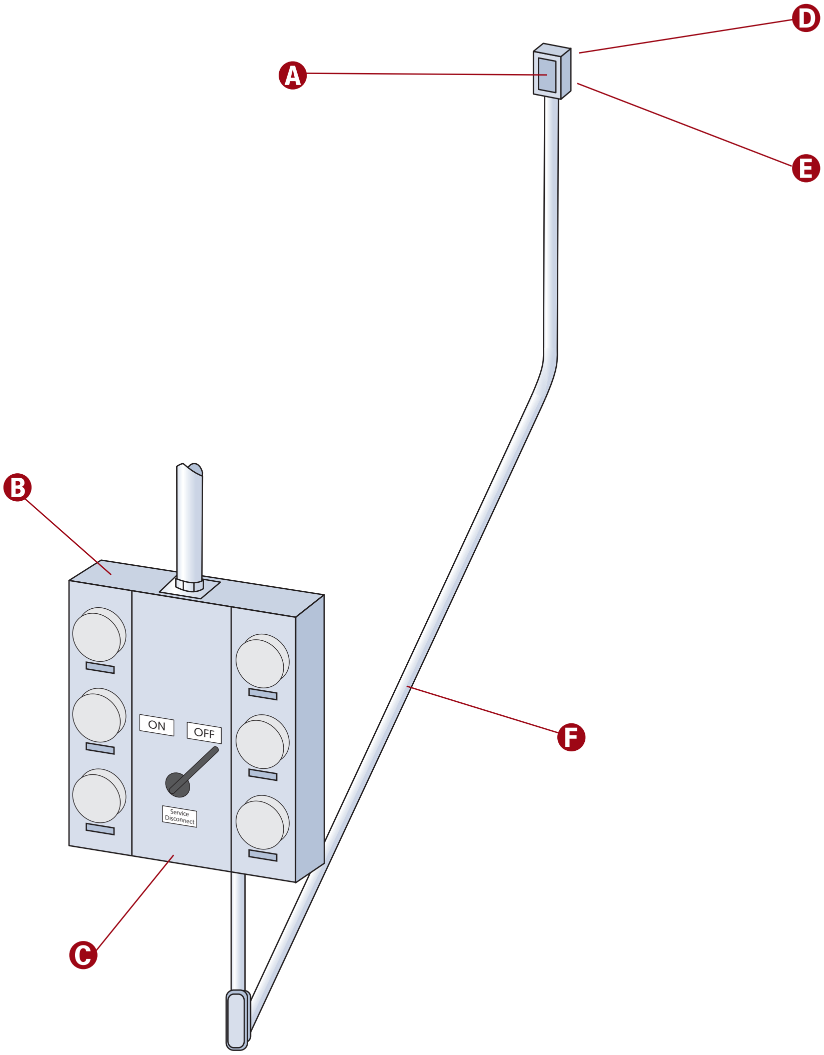
Ⓑ The service disconnecting means must have a rating of at least the calculated load, determined in accordance with Article 220 »*230.79*«.

Ⓒ If the service disconnecting means consists of more than one switch or circuit breaker (permitted by 230.71), the combined ratings of all switches or circuit breakers used must not be less than that required by 230.79 »*230.80*«.

Ⓓ A load calculation must be performed on each unique unit, that is, different from any unit already calculated.

Ⓔ A grounded circuit conductor (neutral) shall not be used for grounding non-current-carrying metal equipment on the load side of the service disconnecting means »*250.142(B)*«. In other words, the neutral must be isolated from the equipment ground in a remote panelboard (subpanel).

Ⓕ For a feeder rated 100 through 400 A, the feeder conductors supplying the entire load associated with an individual dwelling unit in a two-family or multifamily dwelling, shall be permitted to have an ampacity not less than 83% of the feeder rating. If no adjustment or correction factors are required, Table 310.12(A) shall be permitted to be applied »*310.12(B)* and *Table 310.12(A)*«.



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Standard Method—One Unit

A Each identically configured unit—that is, square footage dimensions, small-appliance and laundry branch circuits, fastened-in-place appliances, etc.—results in the same size feeder.

B Although located in a multifamily dwelling, this dwelling unit contains one feeder and one panelboard. It is, therefore, calculated in accordance with one of the one-family dwelling methods.

C A load calculation must be performed on each dissimilar unit.

D Using the standard method, the minimum required volt-amperes for this single unit is 29,048.

Note

Load calculations are calculated for each individual unit containing a panelboard (subpanel). Although located in a multifamily dwelling, calculate each unit by one of the methods for one-family dwellings **»*Article 220*«**. Performing a load calculation on multiple units and then dividing by the number of units will give an incorrect result.

A B C

Standard Method Load Calculation for One-Family Dwellings

1	General Lighting and Receptacle Loads *220.41* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*				3 × 1050 (sq ft outside dimensions) =	**1**	3150
2	Small-Appliance Branch-Circuits *220.52(A)* *Include at least* ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*				1500 × 2 (minimum of two) =	**2**	3000
3	Laundry Branch Circuit(s) *220.52(B)* *Include at least* ***one*** *laundry branch circuit* *unless *meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*				1500 × 1 *(minimum of one) =	**3**	1500
4	Add lines 1, 2, and 3	**4**	7650	Lines 5 through 8 utilize the demand factors found in *Table 220.45.*			
5	7650 (line 4) − 3000 =	**5**	4650 (if 117,000 or less, skip to line 8)	**6**	---- (line 5, if more than 117,000) − 117,000 =	**6**	----
7	---- (line 6) × 25% =	**7**	----	**8**	4650 (smaller of line 5 or 117,000) × 35% =	**8**	1628
9	Total General Lighting and Receptacle Load				3000 + ---- (line 7) + 1628 (line 8) =	**9**	4628
10	Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or Greater *220.53* *Use the nameplate rating.* *Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.*				water heater / 4500 dishwasher / 1200 disposer / 900 compactor / microwave oven / 1200 / / / /		
	If fewer than four units, put total volt-amperes on line 10. If four or more units, multiply total volt-amperes by 75%.				7800 (volt-amps of four or more) × 75% =	**10**	5850
11	Electric Clothes Dryers *220.54* *(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.* The neutral demand load is 70% for services and feeders. *220.61(B)*					**11**	5000
12	Household Electric Cooking Appliances over 1750 Watts *220.55* *(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.* The neutral demand load is 70% for services and feeders. *220.61(B)*					**12**	8000
13	Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60* *Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*					**13**	5345
14	Largest Motor (one motor only) *220.50, 440.32* through *440.35*, and *430.24* through *430.26* *Multiply the volt-amperes of the largest motor by 25%.* *If 25% of the largest motor is in Line 13, leave Line 14 blank.*				900 (volt-amps of largest motor) × 25% =	**14**	225
15	Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.*					**15**	29,048

D

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Minimum Size Feeder and Overcurrent Protection

A Feeder conductors shall have an ampacity not less than required to supply the load as calculated in Parts III, IV, and V of Article 220. Conductors shall be sized to carry not less than the larger of 215.2(A)(1) or (2).

(1) Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum feeder conductor size shall have an allowable ampacity not less than the noncontinuous load plus 125% of the continuous load.

(2) The minimum feeder conductor size shall have an allowable ampacity not less than the maximum load to be served after the application of any adjustment or correction factors. »*215.2(A)(1)* and *(A)(2)*«.

B Feeders must be protected against overcurrent in accordance with the Article 240, Part I provisions »*215.3*«.

C The minimum ampere rating for this one unit is 121 amperes.

D Use Table 310.12(A) to determine the minimum size feeder conductors rated 100 through 400 amperes supplying the entire load associated with an individual dwelling »*310.12(B)*«.

A **B**

16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	29,048 (line 15)	÷	240 (voltage)	=	**16**	121 (minimum amperes)	**Minimum Size 17 Service or Feeder** *240.6(A)*	**17**	125
18 Size the Service or Feeder Conductors. *Use Table 310.12(A) to find the service conductors up to 400 amperes.* *Ratings in excess of 400 amperes shall comply with Table 310.16* *Table 310.12(A) also applies to feeder conductors supplying the entire load.*							**Minimum Size Conductors**	**18**	2 copper 1/0 aluminum

C **D**

Minimum Size Neutral and Equipment Grounding Conductors

A The minimum neutral-conductor ampacity is 74.

B At 75°C (167°F), the minimum size conductor is 4 AWG copper *or* 3 AWG aluminum.

C If a feeder supplies branch circuits requiring equipment grounding conductors, it must include (or provide) an equipment grounding conductor to which the equipment grounding conductors of the branch circuits shall be connected »*215.6*«.

D Copper, aluminum, or copper-clad aluminum equipment grounding conductors of the wire type must not be smaller than shown in Table 250.122, but do not have to be larger than the circuit conductors supplying the equipment »*250.122(A)*«.

Note

A raceway or cable sheath acting as the equipment grounding conductor, as provided in 250.118 and 250.134(1), must comply with 250.4(A)(5) or (B)(4) »***250.122(A)***«.

General lighting and receptacles (line 9)	**4628**
Fastened-in-place appliances	
Water heater	0
Dishwasher	1200
In-sink waste disposer	900
Microwave oven	1200
Total	3300
Total fastened-in-place appliances (3 units = 100%)	**3300**
Clothes dryer (line 11 × 70%)	**3500**
Range (line 12 × 70%)	**5600**
Electric heat	**0**
Air-conditioner compressor	**0**
Air handler (3 × 115)	**345**
Condenser fan motor (2 × 115)	**230**
Largest motor (900 × 25%)	**225**
TOTAL	**17,828**

A **17,828 ÷ 240 = 74.28 minimum neutral-conductor ampacity**

B

19 Size the Neutral Conductor. *220.61* *310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	**19**	4 copper 3 aluminum
20 Size the Grounding Electrode Conductor. *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	**20**	6 copper 4 aluminum

C **D**

The following page shows the completed one-family dwelling load calculation for one multifamily dwelling-unit feeder and remote panelboard (subpanel), according to the standard method.

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Standard Method Load Calculation for One-Family Dwellings

1 General Lighting and Receptacle Loads *220.41* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*	3 × 1050 (sq ft outside dimensions) =	1	3150
2 Small-Appliance Branch-Circuits *220.52(A)* *Include at least* ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*	1500 × 2 (minimum of two) =	2	3000
3 Laundry Branch Circuit(s) *220.52(B)* *Include at least* ***one*** *laundry branch circuit* *unless *meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*	1500 × 1 *(minimum of one) =	3	1500

4 Add lines 1, 2, and 3	4	7650	Lines 5 through 8 utilize the demand factors found in *Table 220.45.*		
5 7650 (line 4) – 3000 =	5	4650 (if 117,000 or less, skip to line 8)	**6** ---- (line 5, if more than 117,000) – 117,000 =	6	----
7 ---- (line 6) × 25% =	7	----	**8** 4650 (smaller of line 5 or 117,000) × 35% =	8	1628

9 Total General Lighting and Receptacle Load	3000 + ---- (line 7) + 1628 (line 8) =	9	4628
10 Fastened-In-Place Appliances Rated ¼ hp or 500 Watts or Greater *220.53* *Use the nameplate rating.* *Do not include electric cooking equipment, clothes dryers, space-heating equipment, air-conditioning equipment, or electric vehicle supply equipment.*	water heater / 4500 dishwasher / 1200 disposer / 900 compactor / microwave oven / 1200 / / / /		
If fewer than four units, put total volt-amperes on line 10. If four or more units, multiply total volt-amperes by 75%.	7800 (volt-amps of four or more) × 75% =	10	5850
11 Electric Clothes Dryers *220.54* *(If present; otherwise skip to line 12.) Use 5000 watts or the nameplate rating, whichever is larger.* The neutral demand load is 70% for services and feeders. *220.61(B)*		11	5000
12 Household Electric Cooking Appliances over 1750 Watts *220.55* *(If present; otherwise skip to line 13.) Use Table 220.55 and all of the applicable Notes.* The neutral demand load is 70% for services and feeders. *220.61(B)*		12	8000
13 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.60* *Include the air handler when using either one. For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*		13	5345
14 Largest Motor (one motor only) *220.50, 440.32* through *440.35*, and *430.24* through *430.26* *Multiply the volt-amperes of the largest motor by 25%.* *If 25% of the largest motor is in Line 13, leave Line 14 blank.*	900 (volt-amps of largest motor) × 25% =	14	225
15 Total Volt-Ampere Demand Load: *Add lines 9 through 14 to find the minimum required volt-amperes.*		15	29,048
16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	29,048 (line 15) ÷ 240 (voltage) = **16** 121 (minimum amperes)	**17** Minimum Size Service or Feeder *240.6(A)*	17 125
18 Size the Service or Feeder Conductors. *Use Table 310.12(A) to find the service conductors up to 400 amperes.* *Ratings in excess of 400 amperes shall comply with Table 310.16* *Table 310.12(A) also applies to feeder conductors supplying the entire load.*	**Minimum Size Conductors**	18	2 copper 1/0 aluminum
19 Size the Neutral Conductor. *220.61* *310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	19	4 copper 3 aluminum
20 Size the Grounding Electrode Conductor. *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	20	6 copper 4 aluminum

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Optional Method: Multifamily Dwellings

Optional Method Load Calculation for Multifamily Dwellings

1 General Lighting and Receptacle Loads *220.84(C)(1)* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.* 3 × ________ (sq ft outside dimensions) × ________ (number of units) =	**1**	
2 Small-Appliance Branch Circuits *220.84(C)(2)* *At least* ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)* 1500 × ________ (minimum of two) × ________ (number of units) =	**2**	
3 Laundry Branch Circuit(s) *220.84(C)(2)* *Include at least* ***one*** *laundry branch circuit *unless meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)* 1500 × ________ *(minimum of one) × ________ (number of units) =	**3**	
4 through 11 Appliances and Motors *220.84(C)(3)* and *(4)* *Use the nameplate rating of* ***all*** *appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, wall-mounted ovens, counter-mounted cooking units, motors, water heaters, and clothes dryers.* *Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.* ***Do not include any heating or air-conditioning equipment in this section.*** water heaters / ________ (volt-amperes each) × ________ (number) =	**4**	
dishwashers / ________ (volt-amperes each) × ________ (number) =	**5**	
disposers / ________ (volt-amperes each) × ________ (number) =	**6**	
clothes dryers / ________ (volt-amperes each) × ________ (number) =	**7**	
ranges / ________ (volt-amperes each) × ________ (number) =	**8**	
microwave ovens / ________ (volt-amperes each) × ________ (number) =	**9**	
________ / ________ (volt-amperes each) × ________ (number) =	**10**	
________ / ________ (volt-amperes each) × ________ (number) =	**11**	
12 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.84(C)(5)* *Include the air handler when using either one.* *For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.* ________ (volt-amperes each) × ________ (number) =	**12**	
13 Total Volt-Ampere Demand Load: *Multiply total VA by Table 220.84(B) demand factor percentage.* ________ (total volt-amperes from lines 1 through 12) × ________ (*Table 220.84(B)* demand factor) =	**13**	
14 House Load *(If present; otherwise skip to line 15)* *Calculate in accordance with Article 220, Part III.* *Do not include Table 220.84(B) demand factors.*	**14**	----
15 Minimum Amperes *Divide the total volt-amperes by the voltage* ________ (lines 13 and 14) ÷ ________ (voltage) = **15** ________ (minimum amperes) **16 Minimum Size Service or Feeder** ***240.6(A)***	**16**	
17 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)* **Minimum Size Conductors**	**17**	
18 Size the Neutral Conductor. *220.61* ***Note:*** **There is no optional method for calculating the neutral conductor.** *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).* **Minimum Size Neutral Conductor**	**18**	
19 Size the Grounding Electrode Conductor. *250.66* *Use line 17 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 16 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.* **Minimum Size Grounding Electrode Conductor . . .** ***or*** **. . . Equipment Grounding Conductor**	**19**	

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Lines 1 through 3—General Lighting and Receptacle Load

Ⓐ In the **Optional Method,** lines 1, 2, and 3 are calculated exactly as described in the **Standard Method.** (See explanations on page 247.)

Ⓑ The feeder or service multifamily dwelling load can be calculated in accordance with Table 220.84(B) (instead of Article 220, Part III) where all of the following conditions are met: (1) no dwelling unit is supplied by more than one feeder; (2) each dwelling unit is equipped with electric cooking equipment; and (3) each dwelling unit is equipped with either electric space-heating or air-conditioning, or both »*220.84(A)*«.

Ⓒ This optional load calculation is calculated on the same twelve-unit multifamily dwelling used for the standard method (located in the first part of this unit).

Note

When the calculated load for multifamily dwellings, without electric cooking, in Article 220, Part III, exceeds that calculated under Part IV for the identical load, plus electric cooking (based on 8 kW per unit), use the lesser of the two loads ***»220.84(A)(2) Exception«***.

Ⓐ

Ⓑ

Optional Method Load Calculation for Multifamily Dwellings

1	General Lighting and Receptacle Loads *220.84(C)(1)* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*	3 ×	1050 (sq ft outside dimensions)	×	12 (number of units)	=	**1**	37,800
2	Small-Appliance Branch Circuits *220.84(C)(2)* *At least **two** small-appliance branch circuits must be included. 210.11(C)(1)*	1500 ×	2 (minimum of two)	×	12 (number of units)	=	**2**	36,000
3	Laundry Branch Circuit(s) *220.84(C)(2)* *Include at least **one** laundry branch circuit *unless meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*	1500 ×	1 *(minimum of one)	×	12 (number of units)	=	**3**	18,000

Ⓒ

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Lines 4 through 11—All Appliances

A This section includes appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and water heaters »*220.84(C)(3)*«.

B Low-power-factor loads and motors (except air-conditioning motors) are also included »*220.84(C)(4)*«.

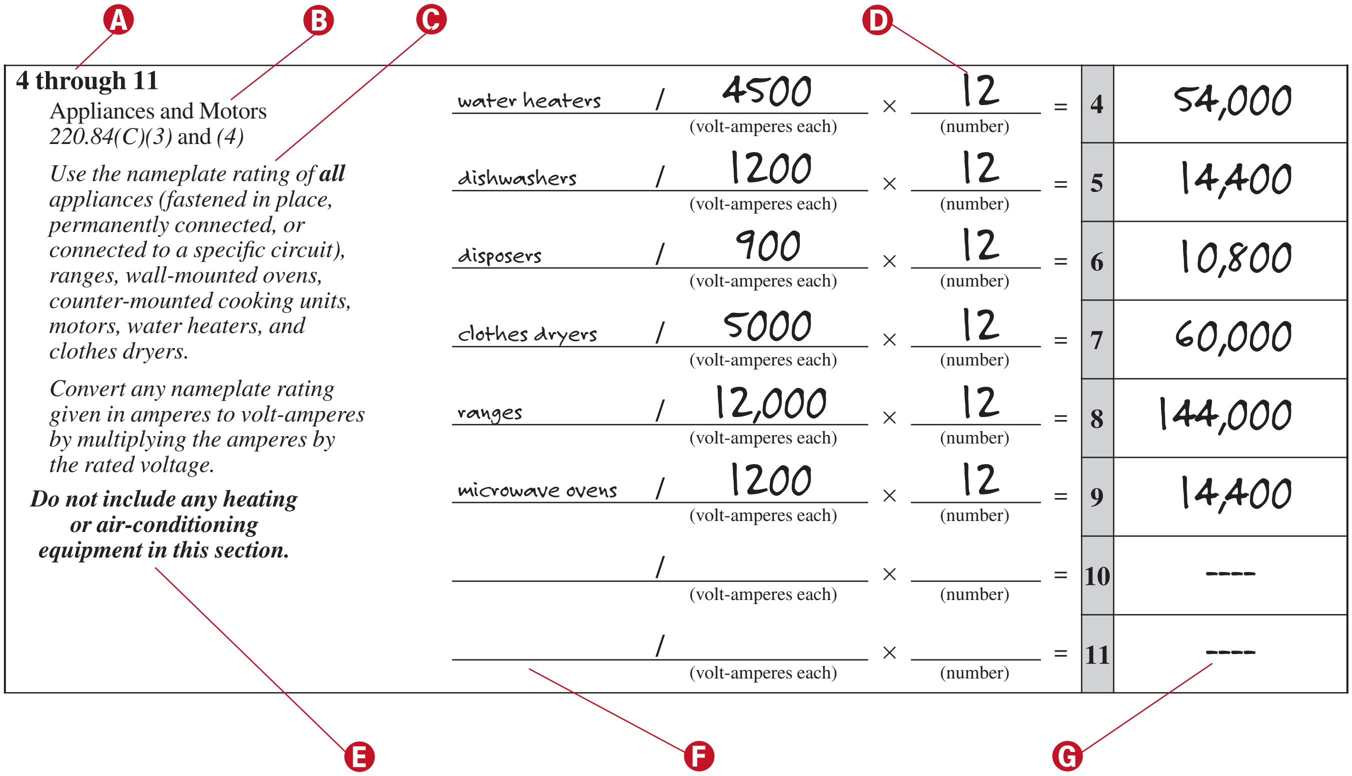
C Use the exact clothes dryer nameplate rating, if any, even if less than 5000 volt-amperes. Do not apply the demand factors in Table 220.55 to household cooking equipment (ranges, cooktops, ovens, etc.); instead, list the nameplate ratings as they appear.

D Insert the number of appliances (such as water heaters) having the same rating, which may not necessarily be the number of dwelling units. Here, all dwelling units contain identical equipment, so the number of each type of appliance is the same as the number of dwelling units. In another application, if only half of the units are equipped with laundry hookups, the number of units is not the same as the number of a given type of appliance.

E Heating and air-conditioning systems are not included in this section of the calculation.

F Additional lines have been provided for listing appliances.

G Inserting numbers in all of the lines is not necessary. However, it is advisable to insert dashes, or some other indicator, to show that the line is intentionally blank.



4 through 11

Appliances and Motors
220.84(C)(3) and *(4)*

Use the nameplate rating of ***all*** *appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, wall-mounted ovens, counter-mounted cooking units, motors, water heaters, and clothes dryers.*

Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.

Do not include any heating or air-conditioning equipment in this section.

	(volt-amperes each)		(number)			
water heaters /	4500	×	12	=	4	54,000
dishwashers /	1200	×	12	=	5	14,400
disposers /	900	×	12	=	6	10,800
clothes dryers /	5000	×	12	=	7	60,000
ranges /	12,000	×	12	=	8	144,000
microwave ovens /	1200	×	12	=	9	14,400
/		×		=	10	----
/		×		=	11	----

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Line 12—Heating or Air-Conditioning System

Ⓐ Include only the larger of the heating or air-conditioning loads (except for heat pumps).

Ⓑ Electric heating loads (including associated motors) are calculated at 100% of the total connected load. Because the air handler (blower) works with either the heating or the air conditioning, add it to both calculations.

Ⓒ Air-conditioning loads (including associated motors) are calculated at 100% of the total connected load. No derating is allowed. Each unit contains an air-conditioner compressor (14 × 230 = 3220 VA), condenser fan motor (2 × 115 = 230 VA), and blower motor (3 × 115 = 345 VA). The combined load is 3795 volt-amperes. Because this is less than the heating load, omit the A/C compressor and the condenser fan motor.

Ⓓ The air handler (blower motor) has a rating of 345 volt-amperes (3 × 115 = 345). Because both loads are energized simultaneously, add the air handler to the 5 kW of electric heat (345 + 5000 = 5345 volt-amperes).

Note

A heat pump with supplementary heat is not considered a noncoincident load. Add the compressor full-load current to the maximum amount of heat that can be energized while the compressor is running. Remember to include all associated motor(s), that is, blower, condenser, etc.

Ⓐ Ⓑ Ⓒ

12 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.84(C)(5)*
Include the air handler when using either one.
For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.
5345 (volt-amperes each) × 12 (number) = **12** 64,140

Ⓓ

Line 13—Total Volt-Ampere Demand Load

Ⓐ Adding lines 1 through 12 results in the volt-ampere load before derating.

Ⓑ Table 220.84(B) contains demand factors (percentages) for derating three (or more) multifamily dwelling units. Find the number of dwelling units in the first column and follow that row across to the demand factor. The demand factors listed in the second column are percentages. The demand factor for a twelve-unit multifamily dwelling is 41 (41%).

Ⓒ This is the total calculated load excluding house loads (if any).

Ⓐ Ⓑ Ⓒ

13 Total Volt-Ampere Demand Load:
Multiply total VA by Table 220.84(B) demand factor percentage.
453,540 (total volt-amperes from lines 1 through 12) × 41% (*Table 220.84(B)* demand factor) = **13** 185,951

Line 14—House Load

Ⓐ House loads must be calculated as stipulated in Article 220, Part III, and must be in addition to the dwelling-unit loads calculated in accordance with Table 220.84 »*220.84(B)*«.

Ⓑ House loads include areas such as clubhouse, office, hallway and stairway lighting, parking lot lighting, etc.

Ⓒ Insert a line (or dashes) in spaces left empty intentionally.

Ⓐ Ⓑ Ⓒ

14 House Load *(If present; otherwise skip to line 15)*
Calculate in accordance with Article 220, Part III.
Do not include Table 220.84(B) demand factors.
14 ----

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Lines 15 and 16—Minimum Service or Feeder

A Place the sum of lines 13 and 14 (total volt-amperes) here. If there is no house load, insert only line 13.

B Fill in the source voltage supplying the service equipment.

C Fractions of an ampere 0.5 and greater are rounded up, while fractions less than 0.5 are dropped (185,951 ÷ 240 = 774.8 = 775) »*220.5(B)*«. The minimum ampere rating required for conductors and overcurrent protection, whether for the service or feeder, is 775.

D The service (or feeder) overcurrent protection must be higher than the number found in line 15. Standard ampere ratings for fuses and circuit breakers are listed in Table 240.6(A).

E The next standard size fuse or breaker above 775 amperes is 800 »*Table 240.6(A)*«.

15 Minimum Amperes *Divide the total volt-amperes by the voltage*	185,951 (lines 13 and 14)	÷	240 (voltage)	=	**15**	775 (minimum amperes)	**16** **Minimum Size Service or Feeder** ***240.6(A)***	**16**	800

Line 17—Minimum Size Conductors

A The total combined rating of paralleled conductors must meet or exceed the minimum calculated load.

B At 75°C (167°F), the minimum size copper conductors for three parallel sets matching or exceeding 775 amperes are 300 kcmil. Although three paralleled sets of 250-kcmil copper conductors (at 75°C [167°F]) are sufficient for an 800-ampere overcurrent protective device, they are not sufficient for the 775-ampere calculated load. (Three times 255 is only 765 amperes, short of the necessary 775 rating.)

17 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	**17**	300 kcmil Cu 400 kcmil Al three paralleled sets

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Line 18—Minimum Size Neutral Conductors

A There is no optional method for neutral conductor calculation. This neutral calculation is performed in accordance with Article 220, Parts II and III.

B The loads for clothes dryers and ranges have already been calculated and are in the "Standard Method Load Calculation for One-Family Dwellings" form, Lines 11 and 12. (See page 254.) As permitted in 220.61(B)(1), apply a 70% demand factor to these loads.

C The minimum calculated volt-ampere load is 109,125.

D The minimum neutral ampacity is 379.

E The minimum rating for three paralleled sets of neutral conductors is 126 amperes each.

F The loads for general lighting and receptacles have already been calculated and are in the "Standard Method Load Calculation for One-Family Dwellings" form, Line 9.

G At 75°C (167°F), the minimum size copper conductor is 1 AWG, with an individual rating of 130 amperes. However, parallel conductors are only allowed in sizes 1/0 AWG and larger. » *Tables 310.16, 250.24(D)(2),* and *310.10(G)(1)* «.

H At 75°C (167°F), the minimum size aluminum conductor, is 2/0 AWG, with a rating of 135 amperes each. » *250.24(D)(1)* «.

A	**General lighting and receptacles (line 9)**	**34,080** **F**
	Fastened-in-place appliances	
	Water heaters	**0**
	Dishwashers (1200 × 12)	**14,400**
	Waste disposers (7.5 × 120 × 12)	**10,800**
	Microwave ovens (1200 × 12)	**14,400**
	Total	**39,600**
	Total fastened-in-place appliances (39,600 × 75%)	**29,700**
B	**Clothes dryers (line 7 × 70%)**	**19,320**
B	**Ranges (line 8 × 70%)**	**18,900**
	Electric heat	**0**
	Air-conditioner compressors	**0**
	Air handlers (3 × 115 × 12)	**4140**
	Condenser fan motors (2 × 115 × 12)	**2760**
	Largest motor (900 × 25%)	**225**
	TOTAL	**109,125**

C **109,125 ÷ 240 = 454.7 = 455 amperes**
D **455 – 200 = 255 amperes of neutral current in excess of 200 amperes**
E **255 × 70% = 178.5 = 179 amperes calculated neutral load over 200 amperes**
200 + 179 = 379 amperes minimum neutral ampacity
379 ÷ 3 = 126.36 = 126 minimum amperes per neutral conductor

G

18 Size the Neutral Conductor. *220.61* ***Note:* There is no optional method for calculating the neutral conductor.** *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	**18**	1/0 Cu 2/0 Al three paralleled sets

H

Line 19—Grounding Electrode Conductor

A The grounding electrode conductor size is determined by the largest ungrounded conductor (or the equivalent area) if the ungrounded conductors are paralleled. The equivalent area for three parallel sets in this calculation is 900-kcmil copper (3 × 300) *or* 1200-kcmil aluminum (3 × 400).

B The minimum size grounding electrode conductor is 2/0 AWG copper *or* 4/0 AWG aluminum » *Table 250.66* «.

A **B**

19 Size the Grounding Electrode Conductor. *250.66* *Use line 17 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 16 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	**19**	2/0 Cu 4/0 Al

The following page shows the completed optional method for a twelve-unit multifamily dwelling, having all units combined into a single service.

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Optional Method Load Calculation for Multifamily Dwellings

1 General Lighting and Receptacle Loads *220.84(C)(1)* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*	3 × 1050 (sq ft outside dimensions) × 12 (number of units) =	1	37,800
2 Small-Appliance Branch Circuits *220.84(C)(2)* *At least* ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*	1500 × 2 (minimum of two) × 12 (number of units) =	2	36,000
3 Laundry Branch Circuit(s) *220.84(C)(2)* *Include at least* ***one*** *laundry branch circuit *unless meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*	1500 × 1 *(minimum of one) × 12 (number of units) =	3	18,000
4 through 11 Appliances and Motors *220.84(C)(3)* and *(4)* *Use the nameplate rating of* ***all*** *appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, wall-mounted ovens, counter-mounted cooking units, motors, water heaters, and clothes dryers.* *Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.* ***Do not include any heating or air-conditioning equipment in this section.***	water heaters / 4500 (volt-amperes each) × 12 (number) =	4	54,000
	dishwashers / 1200 (volt-amperes each) × 12 (number) =	5	14,400
	disposers / 900 (volt-amperes each) × 12 (number) =	6	10,800
	clothes dryers / 5000 (volt-amperes each) × 12 (number) =	7	60,000
	ranges / 12,000 (volt-amperes each) × 12 (number) =	8	144,000
	microwave ovens / 1200 (volt-amperes each) × 12 (number) =	9	14,400
	/ (volt-amperes each) × (number) =	10	----
	/ (volt-amperes each) × (number) =	11	----
12 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.84(C)(5)* *Include the air handler when using either one.* *For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*	5345 (volt-amperes each) × 12 (number) =	12	64,140
13 Total Volt-Ampere Demand Load: *Multiply total VA by Table 220.84(B) demand factor percentage.*	453,540 (total volt-amperes from lines 1 through 12) × 41% (*Table 220.84(B)* demand factor) =	13	185,951
14 House Load *(If present; otherwise skip to line 15)* *Calculate in accordance with Article 220, Part III.* *Do not include Table 220.84(B) demand factors.*		14	----
15 Minimum Amperes *Divide the total volt-amperes by the voltage*	185,951 (lines 13 and 14) ÷ 240 (voltage) =	15	775 (minimum amperes)
16 **Minimum Size Service or Feeder** ***240.6(A)***		16	800
17 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	17	300 kcmil Cu 400 kcmil Al three paralleled sets
18 Size the Neutral Conductor. *220.61* ***Note:*** **There is no optional method for calculating the neutral conductor.** *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	18	1/0 Cu 2/0 Al three paralleled sets
19 Size the Grounding Electrode Conductor. *250.66* *Use line 17 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 16 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	19	2/0 Cu 4/0 Al

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Six-Unit Multifamily Dwelling Calculation—Optional Method

Lines 1 through 12

Ⓐ This optional method calculation is based on six units instead of twelve.

Ⓑ Since everything is calculated at 100%, lines 1 through 12 are exactly half of that calculated for twelve units.

Ⓐ

Optional Method Load Calculation for Multifamily Dwellings

1 General Lighting and Receptacle Loads *220.84(C)(1)* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*	3 ×	1050 (sq ft outside dimensions)	×	6 (number of units)	=	**1**	18,900
2 Small-Appliance Branch Circuits *220.84(C)(2)* *At least **two** small-appliance branch circuits must be included. 210.11(C)(1)*	1500 ×	2 (minimum of two)	×	6 (number of units)	=	**2**	18,000
3 Laundry Branch Circuit(s) *220.84(C)(2)* *Include at least **one** laundry branch circuit *unless meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*	1500 ×	1 *(minimum of one)	×	6 (number of units)	=	**3**	9000
4 through 11 Appliances and Motors *220.84(C)(3)* and *(4)* *Use the nameplate rating of **all** appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, wall-mounted ovens, counter-mounted cooking units, motors, water heaters, and clothes dryers.* *Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.* ***Do not include any heating or air-conditioning equipment in this section.***	water heaters /	4500 (volt-amperes each)	×	6 (number)	=	**4**	27,000
	dishwashers /	1200 (volt-amperes each)	×	6 (number)	=	**5**	7200
	disposers /	900 (volt-amperes each)	×	6 (number)	=	**6**	5400
	clothes dryers /	5000 (volt-amperes each)	×	6 (number)	=	**7**	30,000
	ranges /	12,000 (volt-amperes each)	×	6 (number)	=	**8**	72,000
	microwave ovens /	1200 (volt-amperes each)	×	6 (number)	=	**9**	7200
	/	(volt-amperes each)	×	(number)	=	**10**	----
	/	(volt-amperes each)	×	(number)	=	**11**	----
12 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.84(C)(5)* *Include the air handler when using either one.* *For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*		5345 (volt-amperes each)	×	6 (number)	=	**12**	32,070

Ⓑ

Line 13—Total Volt-Ampere Demand Load

Ⓐ Add lines 1 through 12 to find the volt-ampere load before derating.

Ⓑ Find the demand factor, located in Table 220.84(B), and insert here. The demand factor for a six-unit multifamily dwelling is 44 (44%).

Ⓐ Ⓑ

13 Total Volt-Ampere Demand Load: *Multiply total VA by Table 220.84(B) demand factor percentage.*	226,770 (total volt-amperes from lines 1 through 12)	×	44% (*Table 220.84(B)* demand factor)	=	**13**	99,779

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Lines 15 and 16—Minimum Service or Feeder

A Place the sum of lines 13 and 14 (total volt-amperes) here. If there is no house load, insert only line 13.

B Insert the source voltage supplying the service equipment.

C The minimum amperage rating required for conductors and overcurrent protection is 416 (99,779 ÷ 240 = 415.75 = 416).

D The minimum service (or feeder) determined by the optional method for these six units is 450 amperes.

E The next standard size fuse or breaker above 416 amperes is 450 » *Table 240.6(A)* «.

Note

The same six units calculated by the standard method require a rating of 600 amperes.

15 Minimum Amperes *Divide the total volt-amperes by the voltage*	**A** 99,779 (lines 13 and 14)	÷	**B** 240 (voltage)	=	**15**	**C** 416 (minimum amperes)	**16** **Minimum Size Service or Feeder *240.6(A)***	**16**	**D** **E** 450

Line 17—Minimum Size Conductors

A Ensure that the total combined rating of paralleled conductors meets or exceeds the minimum calculated load.

B At 75°C (167°F), the minimum size conductors for two parallel sets matching or exceeding 416 amperes are 4/0 AWG copper or 300-kcmil aluminum. The minimum rating for each conductor is 208 amperes.

17 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* **A** *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	**17**	**B** 4/0 Cu 300 kcmil Al two paralleled sets

Lines 18 and 19—Minimum Size Neutral and Grounding Conductors

A Since there is no optional method for the neutral conductor calculation, refer to page 256, which gives the neutral for six units. The result requires a minimum rating of 255 amperes, or 128 amperes each for two paralleled conductors.

B At 75°C (167°F), the minimum size conductors are 1 AWG copper (with a rating of 130 amperes) *or* 2/0 AWG aluminum (with a rating of 135 amperes). However, 250.24(D)(2) and 310.10(G)(1) both require a minimum size of 1/0 for parallel conductors. » *Table 310.16* «.

C The equivalent area for two paralleled conductors in this calculation is 423.2-kcmil copper (2 × 211,600 ÷ 1000) *or* 600-kcmil aluminum (2 × 300). The minimum size grounding electrode conductor is 1/0 AWG copper *or* 3/0 AWG aluminum » *Table 250.66* «.

18 Size the Neutral Conductor. *220.61* **A** ***Note:* There is no optional method for calculating the neutral conductor.** *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	**Minimum Size Neutral Conductor**	**18**	**B** 1/0 Cu 2/0 Al two paralleled sets
19 Size the Grounding Electrode Conductor. *250.66* *Use line 17 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 16 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	**19**	1/0 Cu 3/0 Al **C**

The following page shows the completed optional method for a six-unit multifamily dwelling load calculation.

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Optional Method Load Calculation for Multifamily Dwellings

1 General Lighting and Receptacle Loads *220.84(C)(1)* *Do not include open porches, or unfinished areas not adaptable for future use as a habitable room or occupiable space.*	3 × 1050 (sq ft outside dimensions) × 6 (number of units) =		1	18,900
2 Small-Appliance Branch Circuits *220.84(C)(2)* *At least **two** small-appliance branch circuits must be included. 210.11(C)(1)*	1500 × 2 (minimum of two) × 6 (number of units) =		2	18,000
3 Laundry Branch Circuit(s) *220.84(C)(2)* *Include at least **one** laundry branch circuit *unless meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*	1500 × 1 *(minimum of one) × 6 (number of units) =		3	9000
4 through 11 Appliances and Motors *220.84(C)(3)* and *(4)* *Use the nameplate rating of **all** appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, wall-mounted ovens, counter-mounted cooking units, motors, water heaters, and clothes dryers.* *Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.* ***Do not include any heating or air-conditioning equipment in this section.***	water heaters / 4500 (volt-amperes each) × 6 (number) =		4	27,000
	dishwashers / 1200 (volt-amperes each) × 6 (number) =		5	7200
	disposers / 900 (volt-amperes each) × 6 (number) =		6	5400
	clothes dryers / 5000 (volt-amperes each) × 6 (number) =		7	30,000
	ranges / 12,000 (volt-amperes each) × 6 (number) =		8	72,000
	microwave ovens / 1200 (volt-amperes each) × 6 (number) =		9	7200
	/ (volt-amperes each) × (number) =		10	----
	/ (volt-amperes each) × (number) =		11	----
12 Heating or Air-Conditioning System (Compare the heat and A/C, and omit the smaller.) *220.84(C)(5)* *Include the air handler when using either one.* *For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.*	5345 (volt-amperes each) × 6 (number) =		12	32,070
13 Total Volt-Ampere Demand Load: *Multiply total VA by Table 220.84(B) demand factor percentage.*	226,770 (total volt-amperes from lines 1 through 12) × 44% (*Table 220.84(B)* demand factor) =		13	99,779
14 House Load *(If present; otherwise skip to line 15)* *Calculate in accordance with Article 220, Part III.* *Do not include Table 220.84(B) demand factors.*			14	----
15 Minimum Amperes *Divide the total volt-amperes by the voltage*	99,779 (lines 13 and 14) ÷ 240 (voltage) = **15** 416 (minimum amperes)	**16 Minimum Size Service or Feeder *240.6(A)***	16	450
17 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*		**Minimum Size Conductors**	17	4/0 Cu 300 kcmil Al two paralleled sets
18 Size the Neutral Conductor. *220.61* ***Note:* There is no optional method for calculating the neutral conductor.** *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*		**Minimum Size Neutral Conductor**	18	1/0 Cu 2/0 Al two paralleled sets
19 Size the Grounding Electrode Conductor. *250.66* *Use line 17 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 16 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*		**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	19	1/0 Cu 3/0 Al

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Optional Load Calculation for Each Unit of a Multifamily Dwelling

Optional Method—One Unit

A The first three lines of both the optional and standard methods of one-family dwelling calculations are identical.

B Although located in a multifamily dwelling, this unit contains one feeder and one panelboard. Therefore, it is calculated in accordance with a one-family dwelling method.

C Under certain conditions, a laundry branch circuit is optional in multifamily dwellings »*210.52(F) Exception No. 1 and 2*«.

A B

Optional Method Load Calculation for One Multifamily Dwelling Unit

1	General Lighting and Receptacle Loads *220.82(B)(1)* *Do not include open porches, garages, or unused or unfinished spaces not adaptable for future use.*	3 ×	1050 (sq ft outside dimensions)	=	1	3150
2	Small-Appliance Branch Circuits *220.82(B)(2)* *At least* ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*	1500 ×	2 (minimum of two)	=	2	3000
3	Laundry Branch Circuit(s) *220.82(B)(2)* *Include at least* ***one*** *laundry branch circuit *unless meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*	1500 ×	1 *(minimum of one)	=	3	1500

C

Line 4—Appliances

A This section includes appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, wall-mounted ovens, counter-mounted cooking units, clothes dryers, and water heaters »*220.82(B)(3)*«.

B Motors (except air-conditioning motors) are also included in this section »*220.82(B)(4)*«.

C Heating and air-conditioning systems are **not** part of this calculation.

D Use the exact nameplate rating of the clothes dryer, even if less than 5000 volt-amperes.

Note

Do not apply the demand factors in Table 220.55 to household cooking equipment (ranges, cook tops, and ovens). Instead, list the nameplate ratings as they appear.
Do not increase motor loads by 25% »***220.82(B)(4)***«.

A B C D

4	Appliances *220.82(B)(3)* and *(4)* *Use the nameplate rating of* ***all*** *appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, ovens, cooktops, motors, water heaters, and clothes dryers. Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.*	*Do not include any heating or air-conditioning equipment in this section.*	Total volt-amperes of all appliances LISTED BELOW	4	24,800

water heater /	4500	clothes dryer /	5000	range /	12,000
dishwasher /	1200	disposer /	900	microwave oven /	1200
/		/		/	
/		/		/	
/		/		/	

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Line 5—Applying Demand Factors to Lines 1 through 4

Ⓐ This demand factor is found in 220.82(B).

Ⓑ The newly calculated load includes everything except the heating and air-conditioning systems (3150 + 3000 + 1500 + 24,800).

Ⓒ Because the first 10,000 volt-amperes are calculated at 100%, 10,000 is subtracted here.

Ⓓ The remainder of the load is calculated at 40%.

Ⓔ The result on line 5 will be part of line 7's calculation.

Ⓐ

5 Apply *220.82(B)* demand factor to the total of lines 1 through 4.

32,450 (total of lines 1 through 4) – 10,000 = 22,450 × 40% = 8980 + 10,000 = | **5** | 18,980

Ⓑ Ⓒ Ⓓ Ⓔ

Line 6—Heating or Air-Conditioning Systems

Ⓐ The air-conditioner compressor (14 × 230 = 3220 VA), condenser fan motor (2 × 115 = 230 VA), and blower motor (3 × 115 = 345 VA) have a combined load of 3795 volt-amperes. Calculate the air-conditioning system at 100%.

Ⓑ The electric heat (5000) added to the blower motor (3 × 115 = 345) is 5345 volt-amperes. The heating system is multiplied by 65% and the result placed on line 6d.

Ⓐ Ⓑ

6 Heating or Air-Conditioning System *220.82(C)*
*Use the nameplate ratings in volt-amperes for all applicable systems in lines **a** through **e**.*

a) Air-conditioning and cooling systems, including heat pumps without any supplemental electric heating:
3795 × 100% = | **a)** | 3795

b) Electric thermal storage and other heating systems where the usual load is expected to be continuous at full nameplate value. *Systems qualifying under this selection shall not be figured under any other selection in 220.82(C).*
______ × 100% = | **b)** |

c) Supplemental electric heating for heat-pump systems. Include the heat-pump compressors at 100%. *Where heat-pump compressors are prevented from operating with supplemental heat, omit the compressors:*
______ × 65% = | **c)** |

d) Electric space-heating equipment, if fewer than four separately controlled units:
5345 × 65% = | **d)** | 3474

e) Electric space-heating equipment, if four or more separately controlled units:
______ × 40% = | **e)** |

Line 7—Total Volt-Ampere Demand Load

Ⓐ This is the largest volt-ampere rating of the heating or air-conditioning system(s), after application of demand factors.

Ⓑ This is the volt-ampere demand load from line 5.

Ⓒ This is the total volt-ampere load calculated by the optional method. (For comparison, this one-family dwelling calculated by the standard method is 29,048 volt-amperes.)

Ⓐ Ⓑ Ⓒ

7 Total Volt-Ampere Demand Load: 3795 (largest VA rating from lines 6a through 6e) + 18,980 (line 5) = | **7** | 22,775

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Lines 8 and 9—Minimum Feeder

Ⓐ This is the volt-ampere load from line 7.

Ⓑ This is the source voltage.

Ⓒ Because the fraction is more than 0.5, the number 94.9 is rounded up to 95.

Ⓓ The overcurrent protection chosen for this feeder must be higher than the number found on line 8. Standard ampere ratings for fuses and circuit breakers are listed in Table 240.6(A).

Ⓔ This dwelling unit, calculated in accordance with the optional method, requires a 100-ampere feeder and panelboard.

Ⓕ A 100-ampere minimum restriction has been placed on this optional method for both services and feeders »*220.82(A)*«. Feeders calculated in accordance with Article 220, Part III, are not restricted to a minimum rating of 100 amperes.

Note

For comparison, this same dwelling unit calculated by the standard method requires a minimum of 125 amperes.

8	Minimum Amperes *Divide the total volt-amperes by the voltage.*	Ⓐ 22,775 (line 7)	÷	Ⓑ 240 (voltage)	=	**8**	Ⓒ 95 (minimum amperes)	**9**	Ⓓ **Minimum Size Service or Feeder *240.6(A)***	**9**	Ⓔ 100 (minimum is 100 amperes) Ⓕ

Line 10—Minimum Size Conductors

Ⓐ Use 310.12 to select feeder conductors supplying the entire load associated with an individual dwelling.

Ⓑ Select the conductor from Table 310.12(A). The minimum size copper conductor is 4 AWG.

In accordance with the 75°C column of Table 310.16, the ampacity of a 4 AWG copper conductor is 85 amperes.

In accordance with the 75°C column of Table 310.16, the ampacity of a 2 AWG aluminum conductor is 90 amperes.

10 Size the Service or Feeder Conductors. Ⓐ *Use Table 310.12(A) to find the service conductors up to 400 amperes.* *Ratings in excess of 400 amperes shall comply with Table 310.16* *Table 310.12(A) also applies to feeder conductors supplying the entire load.*	**Minimum Size Conductors**	**10**	Ⓑ 4 copper 2 aluminum

Lines 11 and 12—Minimum Size Neutral and Equipment Grounding Conductors

Ⓐ Since there is no optional method for neutral calculation, refer to page 260 for a detailed analysis.

Ⓑ At 75°C (167°F), the minimum size neutral conductor is 4 AWG copper *or* 3 AWG aluminum.

Ⓒ Because these are feeder, not service, conductors, use Table 250.122 to size the equipment grounding conductor. »215.6«.

Ⓓ The minimum size equipment grounding conductor for a 100-ampere overcurrent protective device is 8 AWG copper *or* 6 AWG aluminum »*Table 250.122*«.

11 Size the Neutral Conductor. *220.61* ***Note:* There is no optional method for calculating the neutral conductor.** *310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.* *250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).*	Ⓐ **Minimum Size Neutral Conductor**	**11**	Ⓑ 4 copper 3 aluminum
12 Size the Grounding Electrode Conductor. *250.66* *Use line 10 to find the grounding electrode conductor in 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 9 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor** Ⓒ	**12**	8 copper 6 aluminum Ⓓ

The following page shows the completed optional method load calculation for a feeder and remote panelboard (subpanel) for one unit of a multifamily dwelling.

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Optional Method Load Calculation for One Multifamily Dwelling Unit

1 General Lighting and Receptacle Loads *220.82(B)(1)*
Do not include open porches, garages, or unused or unfinished spaces not adaptable for future use.
3 × 1050 (sq ft outside dimensions) = **1** 3150

2 Small-Appliance Branch Circuits *220.82(B)(2)*
At least ***two*** *small-appliance branch circuits must be included. 210.11(C)(1)*
1500 × 2 (minimum of two) = **2** 3000

3 Laundry Branch Circuit(s) *220.82(B)(2)*
Include at least ***one*** *laundry branch circuit *unless meeting 210.52(F), Exception No. 1 or 2. 210.11(C)(2)*
1500 × 1 *(minimum of one) = **3** 1500

4 Appliances *220.82(B)(3)* and *(4)*
Use the nameplate rating of ***all*** *appliances (fastened in place, permanently connected, or connected to a specific circuit), ranges, ovens, cooktops, motors, water heaters, and clothes dryers. Convert any nameplate rating given in amperes to volt-amperes by multiplying the amperes by the rated voltage.*
Do not include any heating or air-conditioning equipment in this section.
Total volt-amperes of all appliances LISTED BELOW **4** 24,800

water heater / 4500	clothes dryer / 5000	range / 12,000
dishwasher / 1200	disposer / 900	microwave oven / 1200
/	/	/
/	/	/
/	/	/

5 Apply *220.82(B)* demand factor to the total of lines 1 through 4.
32,450 (total of lines 1 through 4) – 10,000 = 22,450 × 40% = 8980 + 10,000 = **5** 18,980

6 Heating or Air-Conditioning System *220.82(C)*
Use the nameplate ratings in volt-amperes for all applicable systems in lines ***a*** *through* ***e***.

a) Air-conditioning and cooling systems, including heat pumps without any supplemental electric heating:
3795 × 100% = **a)** 3795

b) Electric thermal storage and other heating systems where the usual load is expected to be continuous at full nameplate value. *Systems qualifying under this selection shall not be figured under any other selection in 220.82(C).*
× 100% = **b)**

c) Supplemental electric heating for heat-pump systems. Include the heat-pump compressors at 100%. *Where heat-pump compressors are prevented from operating with supplemental heat, omit the compressors:*
× 65% = **c)**

d) Electric space-heating equipment, if fewer than four separately controlled units:
5345 × 65% = **d)** 3474

e) Electric space-heating equipment, if four or more separately controlled units:
× 40% = **e)**

7 Total Volt-Ampere Demand Load: 3795 (largest VA rating from lines 6a through 6e) + 18,980 (line 5) = **7** 22,775

8 Minimum Amperes
Divide the total volt-amperes by the voltage.
22,775 (line 7) ÷ 240 (voltage) = **8** 95 (minimum amperes)

9 **Minimum Size Service or Feeder** ***240.6(A)*** **9** 100 (minimum is 100 amperes)

10 Size the Service or Feeder Conductors.
Use Table 310.12(A) to find the service conductors up to 400 amperes. Ratings in excess of 400 amperes shall comply with Table 310.16
Table 310.12(A) also applies to feeder conductors supplying the entire load.
Minimum Size Conductors **10** 4 copper
2 aluminum

11 Size the Neutral Conductor. *220.61*
Note: **There is no optional method for calculating the neutral conductor.**
310.12(D) states that the neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.
250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1).
Minimum Size Neutral Conductor **11** 4 copper
3 aluminum

12 Size the Grounding Electrode Conductor. *250.66*
Use line 10 to find the grounding electrode conductor in 250.66.
Size the Equipment Grounding Conductor (for Feeder). *250.122*
Use line 9 to find the equipment grounding conductor in Table 250.122.
Equipment grounding conductor types are listed in 250.118.
Minimum Size Grounding Electrode Conductor . . . ***or*** **. . . Equipment Grounding Conductor** **12** 8 copper
6 aluminum

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Summary

- Multifamily dwelling calculations are a progression of the one-family dwelling calculations (standard and optional).
- Some of the information needed for each individual dwelling unit includes total square-foot area, the number of small-appliance branch circuits and laundry branch circuits (if any), appliance ratings, dryer ratings (if any), cooking equipment ratings, and heating and air-conditioning loads.
- Identifying the number of dwelling units supplied by each service or disconnecting means is essential to the performance of multifamily load calculations.
- In certain instances, the laundry branch circuit may be omitted from both the dwelling unit and the calculation.
- Laundry (if installed) and small-appliance branch circuits are calculated using a rating of at least 1500 volt-amperes each.
- Table 220.45 demand factors are applied to general lighting, small-appliance, and laundry loads.
- The total volt-ampere rating of four (or more) fastened-in-place appliances is multiplied by 75% in the standard method calculation.
- Demand factors for household electric clothes dryers are found in Table 220.54.
- Table 220.55 lists the demand loads for household electric cooking appliances (over 1¾-kW rating).
- The heating and air-conditioning loads are compared, and the larger of the two is used.
- For heat pumps, include the compressor and the maximum amount of electric heat that can be energized while the compressor is running.
- Two multifamily load calculation methods are provided in Article 220: **Standard** and **Optional.**
- The neutral conductor can be smaller than the ungrounded (hot) conductors, provided the requirements of 215.2, 220.61, and 230.42 are met.
- Table 250.66 is used to size grounding electrode conductors.
- Remote panelboards (subpanels) require equipment grounding conductors, which can be one, more, or a combination of the types listed in 250.118.
- Equipment grounding conductors are sized in accordance with Table 250.122.
- The list of standard ampere ratings for fuses and inverse time circuit breakers is in Table 240.6(A).

Unit 11 Competency Test

***NEC*® Reference** **Answer**

____________ ____________ 1. A 125-ampere feeder is supplying a 240-volt panelboard in a multifamily dwelling. The conductors will be XHHW aluminum conductors and all terminations will be rated 75°C (167°F). What is the minimum size aluminum equipment grounding conductor required?

____________ ____________ 2. What is the minimum calculated service load (in kW) for 25- to 4.5-kW electric clothes dryers installed in a multifamily dwelling unit? (The service is 120/240-volt, single-phase.)

____________ ____________ 3. A four-unit apartment building contains the following electric ranges: a 15 kW, a 14 kW, a 10 kW, and a 9 kW. What is the minimum calculated service load for these ranges?

____________ ____________ 4. An eighteen-unit multifamily dwelling contains the following appliances in each unit: a 1-kVA, 115-volt dishwasher; a ⅓-horsepower, 115-volt in-sink waste disposer; and a 4500-watt, 230-volt water heater. Using the standard method, what is the minimum calculated neutral load, in volt-amperes, for these appliances?

____________ ____________ 5. A multifamily dwelling's service-entrance conductors consist of four paralleled sets of 3/0 AWG THHN copper conductors. What minimum size copper grounding electrode conductor is required?

____________ ____________ 6. A 5.4-kVA, 240-volt electric clothes dryer will contribute ____________ amperes to the neutral load, when calculating the service by the standard method.

____________ ____________ 7. What is the minimum calculated service load for twenty 6.5-kW electric ranges in a multifamily dwelling?

____________ ____________ 8. A service load calculation will need to be performed on a multifamily dwelling. Twelve dwelling units will be supplied by this service. What required load in volt amperes (before applying lighting load demand factors in Table 220.45) shall be added into the load calculation for laundry branch circuits? This multifamily building will have laundry facilities on the premises that will be available for all building occupants to use.

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***NEC*® Reference** **Answer**

____________ ____________ 9. Two paralleled sets of 500-kcmil copper service-entrance conductors supply a multifamily dwelling service disconnecting means. What is the minimum size aluminum grounding electrode conductor required?

____________ ____________ 10. A fifty-unit apartment building has a 4.5-kW electric clothes dryer in each apartment. By using the optional method, what is the minimum calculated service load for these appliances?

Questions 11 through 18 are based on a 120/240-volt, 3-wire, single-phase, eight-unit multifamily dwelling. The eight identical units contain the following:

Floor area	1200 ft^2
Range	$8\frac{3}{4}$ kW, 240 volt
Water heater	4 kW, 240 volt
Dishwasher	1 kW, 120 volt
Electric clothes dryer	5 kW, 240 volt
Electric heat	4.2 kW, 240 volt
Air handler (blower motor)	$\frac{1}{4}$ hp, 115 volt
Air-conditioner compressor	14 amps, 230 volt
Condenser fan motor	$\frac{1}{6}$ hp, 115 volt

Assume water heater, clothes dryer, range, and electric heat kW ratings equivalent to kVA.

Using Article 220, Parts II and III (the standard method):

____________ ____________ 11. What is the service demand load for the clothes dryers?

____________ ____________ 12. What is the service demand load for the cooking appliances?

____________ ____________ 13. Of the heating or air-conditioning (and associated motors), which is omitted?

____________ ____________ 14. What is the minimum rating (in amperes) for the service overcurrent device?

____________ ____________ 15. A parallel run (two sets) of service-entrance conductors will be installed in two raceways. What is the minimum size THWN copper ungrounded conductors that can be used?

____________ ____________ 16. What is the minimum rating (in amperes) for the neutral conductors?

____________ ____________ 17. What is the minimum size THWN copper neutral (grounded) conductors that can be installed?

____________ ____________ 18. What is the minimum size copper grounding electrode conductor?

Questions 19 through 22 are based on a 120/240-volt, 3-wire, single-phase, six-unit multifamily dwelling. The six identical units contain the following:

Floor area	1350 ft^2
Range	10.6 kW, 240 volt
Water heater	4.2 kW, 240 volt
Dishwasher	1.2 kW, 120 volt
In-sink waste disposer	$\frac{1}{3}$ hp, 115 volt
Electric clothes dryer	4 kW, 240 volt
Electric heat (two banks at 3 kW each)	6 kW, 240 volt
Air handler (blower motor)	$\frac{1}{3}$ hp, 115 volt
Air-conditioner compressor	3 hp, 230 volt
Condenser fan motor	$\frac{1}{6}$ hp, 115 volt

Assume water heater, clothes dryer, range, and electric heat kW ratings equivalent to kVA.

Using Article 220, Part IV (the optional method):

____________ ____________ 19. What is the minimum rating (in amperes) for the service overcurrent device?

____________ ____________ 20. What is the minimum size THWN copper ungrounded conductors that can be installed? (Do not parallel the conductors.)

____________ ____________ 21. What is the minimum size THWN copper neutral (grounded) conductor that can be installed?

____________ ____________ 22. What is the minimum acceptable size copper grounding electrode conductor?

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Section 4

Commercial Locations

Unit 12

General Provisions

Objectives

After studying this unit, the student should be able to:

- recall that commercial occupancy receptacle placement differs from that of one-family and multifamily dwellings.
- determine if receptacle outlets are required in bathrooms located in commercial occupancies.
- recall that each commercial building (or occupancy) accessible to pedestrians must have at least one sign outlet.
- summarize Article 430 motor provisions.
- recall that air-conditioning and refrigeration provisions are found in Article 440.
- determine receptacle volt-ampere ratings for single, duplex, quad, etc.
- calculate the maximum number of receptacles permitted on 15- and 20-ampere branch circuits.
- recall that at least two receptacle outlets must be readily accessible in guest rooms of hotels, motels, and similar occupancies.
- clarify showcase and show window provisions.
- determine an occupancy's general lighting load based on square-foot area.
- summarize general lighting provisions and also specific lighting provisions for fluorescent, HID, recessed, and track-lighting.
- recall that while certain luminaires can be used as raceways, the number of branch circuits permitted therein is limited.
- clarify that a metal pole supporting a luminaire(s) requires a handhole, unless an exception is met.
- explain when an outlet box hood shall be listed and shall be identified as "extra-duty."

Introduction

The broad topic of commercial wiring encompasses many types of structures—office buildings, restaurants, retail spaces, schools, and warehouses, to name a few. In fact, all of the occupancies found in Table 220.42(A) are indeed commercial. Some of the electrical requirements that apply to one-family and multifamily dwellings also apply to commercial and industrial locations. Because this overlap of requirements is common, it is especially important to begin with a solid understanding of not only some but all of the preceding material. Of particular importance are Units 3 through 5 of Section 1, which contain fundamental principles applicable to all types of occupancies. In addition, Unit 9—Services and Electrical Equipment explains one-family dwelling provisions that extend into the realm of commercial wiring systems. Unit 12—General Provisions likewise covers overlapping topics, such as branch circuits, receptacles, and lighting. Because it would be very difficult, if not impossible, to cover such a large field as commercial wiring in the framework of this text, only a small but representative portion is presented. Unit 13—Nondwelling Load Calculations explains nondwelling (inclusive of commercial) load calculations, which are helpful in determining service and feeder loads. Complete subsequent units, and portions of others, apply to commercial wiring as well.

The inception of most commercial electrical projects includes multifaceted plans (blueprints) and detailed specifications. As a reference, illustrations for a retail store's electrical and lighting floor plans are provided. Various general provisions (branch circuits, receptacles, lighting, etc.) and numerous specific provisions (required receptacle outlets, show windows, showcases, etc.) are discussed. Proper receptacle placement is demonstrated through the use of a hotel/motel guest room floor plan, including furniture placement. Receptacle and lighting branch-circuit load calculations are also part of this unit.

While this unit is by no means a complete reference for commercial electrical wiring, taken together with the extensive information presented throughout this text, it does provide a substantial foundation toward understanding commercial electrical wiring systems.

Branch Circuits

General Requirements

Article 210 provides the general requirements for branch circuits not over 1000 volts ac or 1500 volts dc nominal »*210.1*«.

Branch circuits recognized by Article 210 shall be rated in accordance with the maximum permitted ampere rating or setting of the overcurrent device. The rating for other than individual branch circuits shall be 10, 15, 20, 30, 40, and 50 amperes. Where conductors of higher ampacity are used for any reason, the ampere rating or setting of the specified overcurrent device shall determine the circuit rating »*210.18*«.

Unless meeting one of the two exceptions, a single receptacle installed on an individual branch circuit shall have an ampere rating not less than that of the branch circuit »*210.21(B)(1)*«.

An individual branch circuit shall be permitted to supply any load for which it is rated, but in no case shall the load exceed the branch-circuit ampere rating »*210.22*«.

A Branch circuits recognized by Article 210 shall be permitted as multiwire circuits. A multiwire circuit shall be permitted to be considered as multiple circuits. Except as permitted in 300.3(B)(4), all conductors of a multiwire branch circuit shall originate from the equipment containing the branch-circuit overcurrent protective device or protective devices »*210.4(A)*«.

B Conductors shall be sized to carry not less than the larger of 210.19(A)(1) or (A)(2).

(1) Where a branch circuit supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum branch-circuit conductor size shall have an allowable ampacity not less than the noncontinuous load plus 125% of the continuous load.

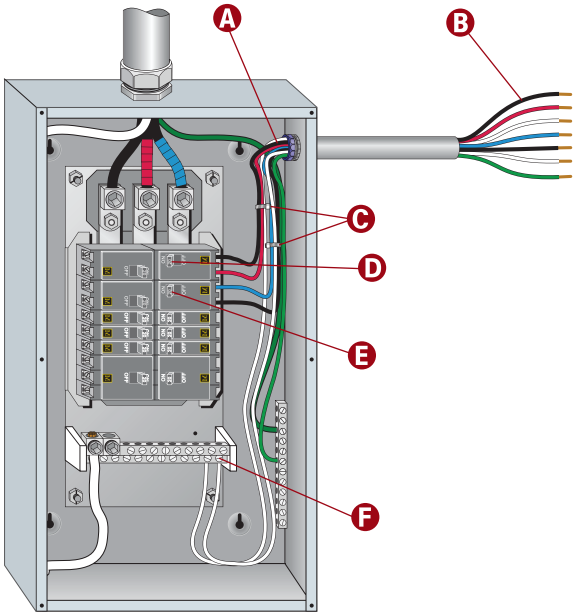
(2) The minimum branch-circuit conductor size shall have an allowable ampacity not less than the maximum load to be served after the application of any adjustment or correction factors »*210.19(A)*«.

C The ungrounded and grounded circuit conductors of each multiwire branch circuit shall be grouped in accordance with 200.4(B) »*210.4(D)*«.

D Each multiwire branch circuit shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point where the branch circuit originates »*210.4(B)*«.

E Where a branch circuit supplies continuous loads, or any combination of continuous and noncontinuous loads, the rating of the overcurrent device must not be less than the noncontinuous load plus 125% of the continuous load »*210.20(A)*«.

F Multiwire branch circuits shall supply only line-to-neutral loads »*210.4(C)*«.



Note

Table 210.3 lists references for specific equipment and applications not located in Chapters 5, 6, and 7 that amend or supplement the requirements of Article 210 »***210.3***«.

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Grouping of Neutral Conductors

A In multiwire branch circuits, the ungrounded and grounded circuit conductors of each multiwire branch circuit shall be grouped in accordance with 200.4(B) »*210.4(D)*«.

B Where more than one neutral conductor associated with different circuits is in an enclosure, grounded circuit conductors of each circuit shall be identified or grouped to correspond with the ungrounded circuit conductor(s) by wire markers, cable ties, or similar means in at least one location within the enclosure »*200.4(B)*«.

C Because more than one neutral conductor associated with different circuits is in this enclosure, even each ungrounded conductor is required to be grouped with its corresponding ungrounded conductor.

D Each multiwire branch circuit shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point where the branch circuit originates »*210.4(B)*«.

E The requirement for grouping or identifying shall not apply where branch-circuit conductors pass through a box or conduit body without a loop as described in 314.16(B)(1) or without a splice or termination »*200.4(B) Exception No. 2*«.

F The requirement for grouping or identifying shall not apply if the branch-circuit or feeder conductors enter from a cable or a raceway unique to the circuit that makes the grouping obvious »*200.4(B) Exception No. 1*«.

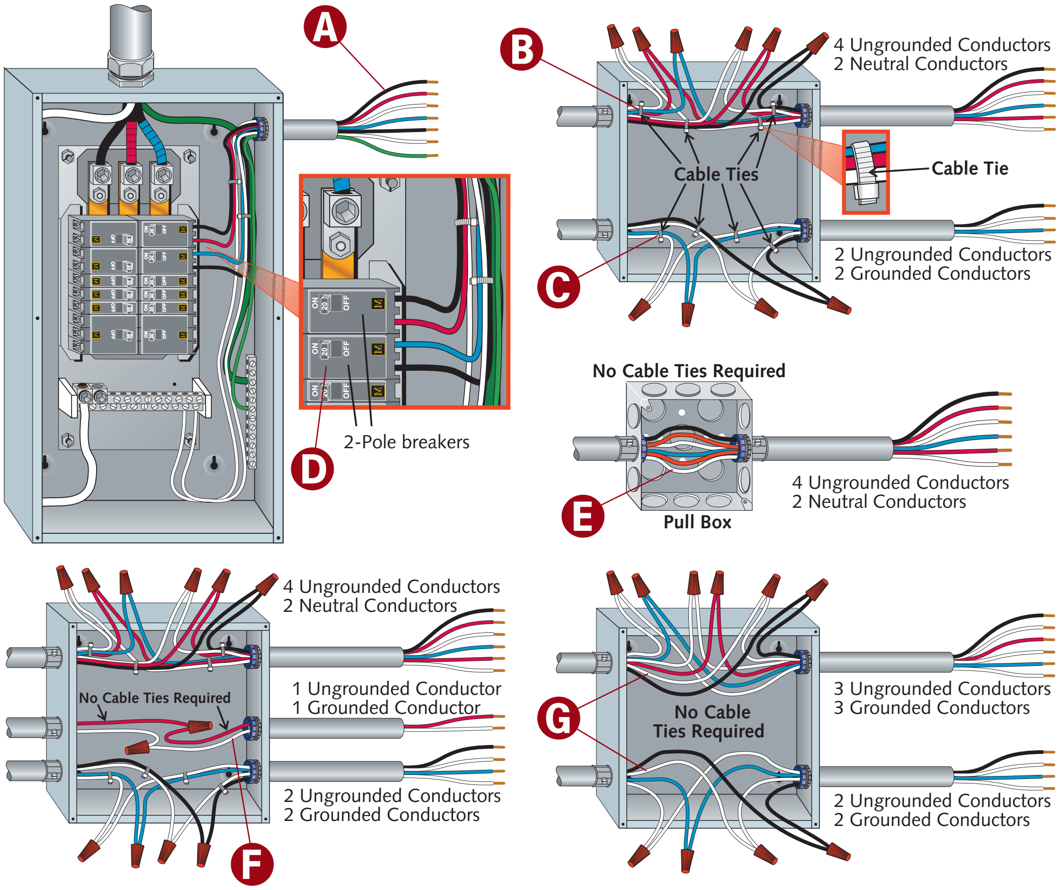
G Although there are five sets of white conductors, none of these conductors meet the definition of a neutral conductor. All five sets of white conductors are grounded conductors and therefore no grouping or identifying is required. If more than one neutral conductor in this enclosure was associated with different circuits, all the white conductors would be required to be grouped with its corresponding ungrounded (hot) conductor.

Note

Branch circuits recognized by Article 210 shall be permitted as multiwire circuits. A multiwire circuit shall be permitted to be considered as multiple circuits. All conductors of a multiwire branch circuit shall originate from the equipment containing the branch-circuit overcurrent protective device or protective devices »***210.4(A)***«.

Caution

Neutral conductors shall not be used for more than one branch circuit, for more than one multiwire branch circuit, or for more than one set of ungrounded feeder conductors unless specifically permitted elsewhere in this Code »*200.4(A)*«.


A
B
4 Ungrounded Conductors
2 Neutral Conductors
Cable Ties
Cable Tie
2 Ungrounded Conductors
2 Grounded Conductors
C
2-Pole breakers
D
No Cable Ties Required
4 Ungrounded Conductors
2 Neutral Conductors
Pull Box
E
4 Ungrounded Conductors
2 Neutral Conductors
No Cable Ties Required
1 Ungrounded Conductor
1 Grounded Conductor
2 Ungrounded Conductors
2 Grounded Conductors
F
No Cable Ties Required
3 Ungrounded Conductors
3 Grounded Conductors
2 Ungrounded Conductors
2 Grounded Conductors
G

Required Sign Outlet

The disconnecting means must be within sight of the sign or outline lighting system that it controls. If out of the line of sight from any section that is able to be energized, the disconnecting means shall be lockable in accordance with 110.25. A permanent field-applied marking identifying the location of the disconnecting means shall be applied to the sign in a location visible during servicing »*600.6(A)(2)*«.

Signs or outline lighting systems operated by external electronic or electromechanical controllers can have a disconnecting means located within sight of the controller or within the controller enclosure. The disconnecting means must disconnect both the sign (or outline lighting system) and the controller from all ungrounded supply conductors. It must be designed so that no pole operates independently and it shall be lockable in accordance with 110.25 »*600.6(A)(3)*«. Where the disconnecting means is not located within sight of the controller, a permanent field-applied marking identifying the location of the disconnecting means shall be applied to the controller in a location visible during servicing »*600.6(A)(3) Exception*«.

Note

A sign or outline lighting outlet is not required at entrances for deliveries, service corridors, or service hallways used only by service personnel or employees »*600.5(A)*«.

Switches, flashers, and similar devices controlling transformers and electronic power supplies must either be rated for controlling inductive loads or have a current rating not less than twice the current rating of the transformer or the electronic power supply »*600.6(B)*«.

Caution

Signs and outline lighting systems shall be listed; marked with the manufacturer's name, trademark, or other means of identification; and input voltage and current rating »*600.4(A)*«.

Ⓐ Each commercial building and occupancy accessible to pedestrians must have at least one accessible outlet at every entrance to each tenant space for sign or outline lighting systems use »*600.5(A)*«.

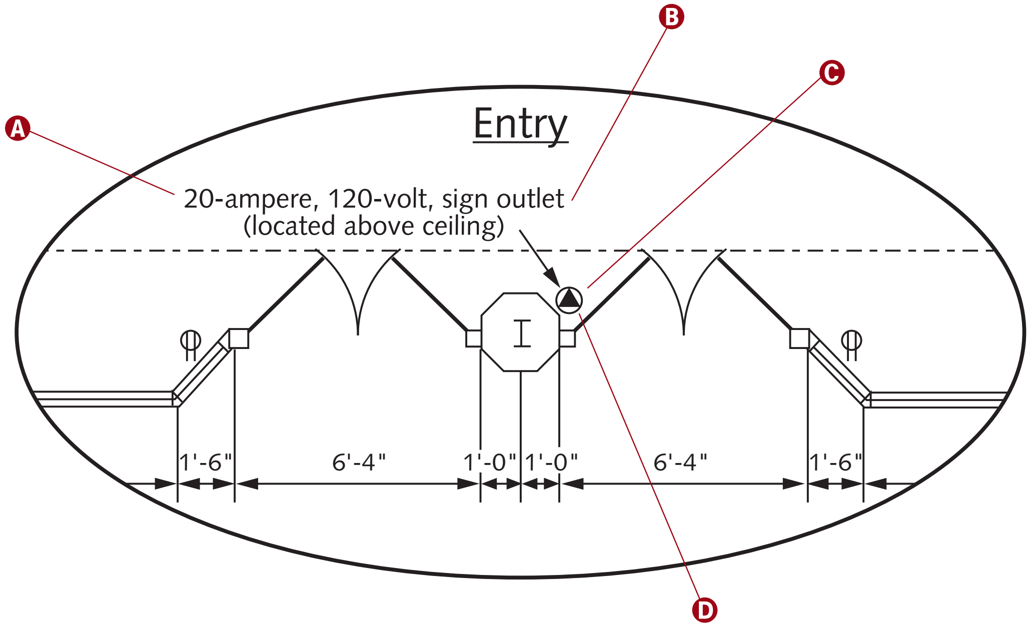
Ⓑ The outlet(s) must be supplied by a branch circuit rated 20 amperes or more and that supplies no other load »*600.5(A)*«.

Ⓒ Each sign and outline lighting system, feeder conductor(s) or branch circuit(s) supplying a sign, outline lighting system, or skeleton tubing must be controlled by an externally operable switch (or circuit breaker) that opens all ungrounded conductors and controls no other load, unless (1) the sign is an exit directional sign located within a building or (2) the sign is cord-connected with an attachment plug. Signs and outline lighting systems located within fountains shall have the disconnect located in accordance with 680.13 »*600.6*«.

Ⓓ Sign and outline lighting outlets must be calculated at a minimum of 1200 volt-amperes per required branch circuit specified in 600.5(A) »*220.14(F)*«.

Note

Where a disconnecting means is required to be lockable open throughout the Code, it shall be capable of being locked in the open position. The provisions for locking shall remain in place with or without the lock installed »*110.25*«.



Commercial (Retail) Occupancy

Equipment and branch-circuit conductors for circuits not exceeding 1000 volts ac or 1500 volts dc must be protected by overcurrent protective devices rated in compliance with 210.20(A) through (D) »*210.20*«.

Outlet devices must have an ampere rating not less than the load served and must comply with 210.21(A) and (B) »*210.21*«.

The requirements for circuits that have two or more outlets or receptacles, other than the receptacle circuits of 210.11(C)(1), (C)(2), and (C)(3), are summarized in Tables 210.24(1) and (2) »*210.24*«.

The minimum number of branch circuits is determined from the total computed load and the size (or rating) of the circuits used. In all installations, the number of circuits must be sufficient to supply the load served. In no case can the load on any circuit exceed the maximum specified by 220.11 »*210.11(A)*«.

Ⓐ A unit load at least equal to that shown in Table 220.42(A) for non-dwelling occupancies and the floor area determined in 220.5(C) shall be used to calculate the minimum lighting load »*220.42(A)*«. Floor area (for each floor) is calculated using the outside dimensions of the building, dwelling unit, or other area involved »*220.5(C)*«. In accordance with Table 220.42(A), the minimum general lighting load for a store is 1.9 volt-amperes per square foot. Stores are considered retail occupancies. This section contains provisions for a building that is designed and constructed to comply with an energy code adopted by the local authority. The minimum general lighting load for this retail space is 2360 volt-amperes ($27 \times 46 = 1242 \times 1.9 = 2359.8 = 2360$).

Ⓑ No receptacle wall placement provisions exist for commercial occupancies. The "6-ft rule," which is the maximum distance to a receptacle (measured horizontally along the wall), applies only to dwelling units »*210.52(A)(1)*«.

Ⓒ Receptacles are not required in nondwelling bathrooms. If installed, however, they must be GFCI protected »*210.8(B)(1)*«.

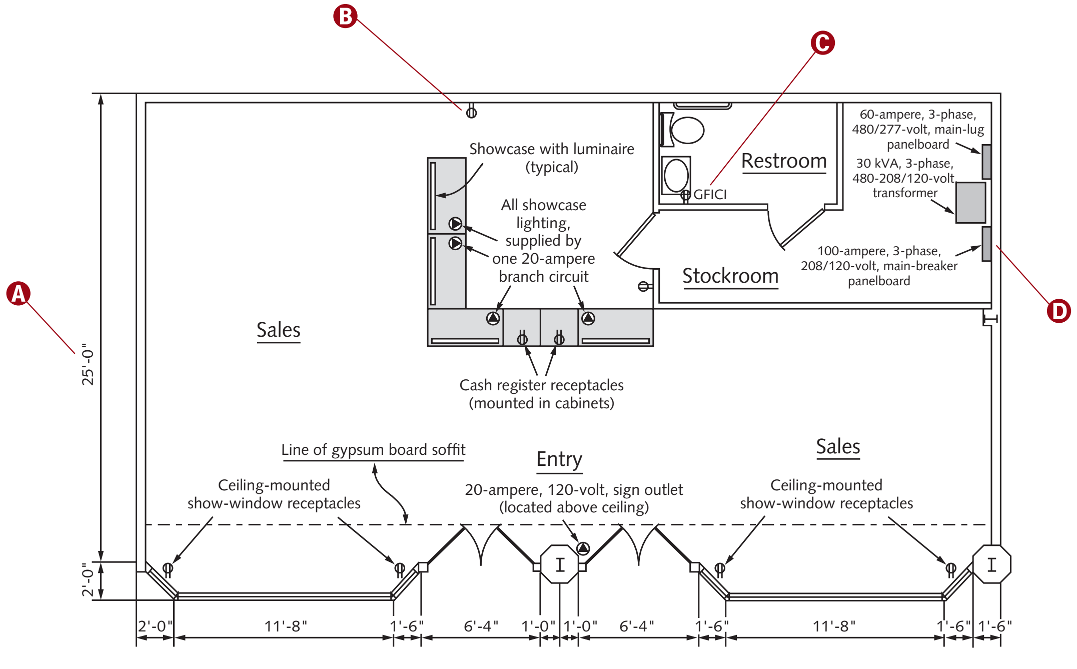
Ⓓ Where the premises wiring system has branch circuits supplied from more than one nominal voltage system, each ungrounded (hot) conductor of a branch circuit must be identified by phase or line and by nominal voltage system at all termination, connection, and splice points. The identification method can be separate color coding, marking tape, tagging, or other approved means. The method utilized for conductors originating within each branch-circuit panelboard or similar branch-circuit distribution equipment must be documented in a manner that is readily available or must be permanently posted at each branch-circuit panelboard on similar branch-circuit distribution equipment. The label shall be of sufficient durability to withstand the environment involved and shall not be handwritten. Different systems within the same premises that have the same system voltage class shall be permitted to use the same identification »*210.5(C)(1)*«.

Note

The provisions for using the minimum volt-ampere unit load in Table 220.42(A) states where the building is designed and constructed to comply with an energy code adopted by the local authority, the lighting load shall be permitted to be calculated using the unit values specified in the energy code where the following conditions are met:
(1) A power monitoring system is installed that will provide continuous information regarding the total general lighting load of the building.
(2) The power monitoring system will be set with alarm values to alert the building owner or manager if the lighting load exceeds the values set by the energy code.
(3) The demand factors specified in 220.45 are not applied to the general lighting load.
(4) The continuous load multiplier of 125% shall be applied ***»220.42(B)«***.

Note

The 125% multiplier for a continuous load as specified in 210.20(A) is included when using the unit loads in Table 220.42(A) for calculating the minimum lighting load for a specified occupancy ***»Note to Table 220.42(A)«***.


B
C
D
A
Showcase with luminaire (typical)
All showcase lighting, supplied by one 20-ampere branch circuit
GFICI
Restroom
60-ampere, 3-phase, 480/277-volt, main-lug panelboard
30 kVA, 3-phase, 480-208/120-volt transformer
100-ampere, 3-phase, 208/120-volt, main-breaker panelboard
Stockroom
Sales
Cash register receptacles (mounted in cabinets)
Line of gypsum board soffit
Entry
Sales
Ceiling-mounted show-window receptacles
20-ampere, 120-volt, sign outlet (located above ceiling)
Ceiling-mounted show-window receptacles
25'-0"
2'-0"
2'-0"
11'-8"
1'-6"
6'-4"
1'-0"
1'-0"
6'-4"
1'-6"
11'-8"
1'-6"
1'-6"

Showcases

Ⓐ Individual moveable showcases can be connected by flexible cord to permanently installed receptacles. Groups of not more than six such showcases can be coupled together (by flexible cord and separable locking-type connectors) provided one of the group is connected (by flexible cord) to a permanently installed receptacle. The installation must comply with 410.59(A) through (E) »*410.59*«.

Ⓑ Flexible cords must be secured to showcase undersides so that (1) wiring will not be exposed to physical damage; (2) cases cannot separate more than 2 in. (50 mm), nor can the first case extend more than 12 in. (300 mm) from the supply receptacle; and (3) the free lead at the end of the showcase group has a female fitting that does not extend beyond the case »*410.59(C)*«.

Ⓒ In cord-connected showcases, the secondary circuit(s) of each electric-discharge lighting ballast is (are) limited to one showcase »*410.59(E)*«.

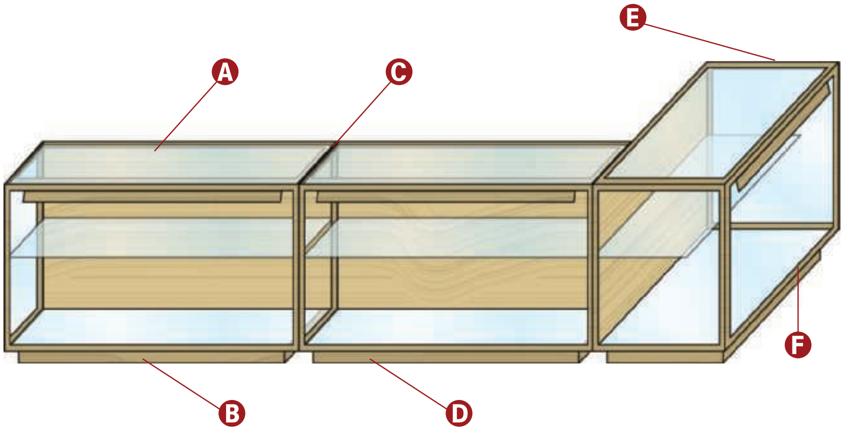
Ⓓ Flexible cord must be hard-service type, have conductors not smaller than the branch-circuit conductors, having ampacity at least equal to the branch-circuit overcurrent device, and have an equipment grounding conductor »*410.59(A)*«.

Ⓔ Receptacles, connectors, and attachment plugs must be of a listed grounding type, rated 15 or 20 amperes »*410.59(B)*«.

Ⓕ Unless used in wiring of chain-supported luminaires or as supply cords for portable luminaires and other merchandise being displayed or exhibited, flexible cords used in showcases and show windows must be Type S, SE, SEO, SEOO, SJ, SJE, SJEO, SJEOO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, STOO, SEW, SEOW, SEOOW, SJEW, SJEOW, SJEOOW, SJOW, SJOOW, SJTW, SJTOW, SJTOOW, SOW, SOOW, STW, STOW, or STOOW »*400.15*«.

Note

Other equipment must not be electrically connected to showcases »***410.59(D)***«.



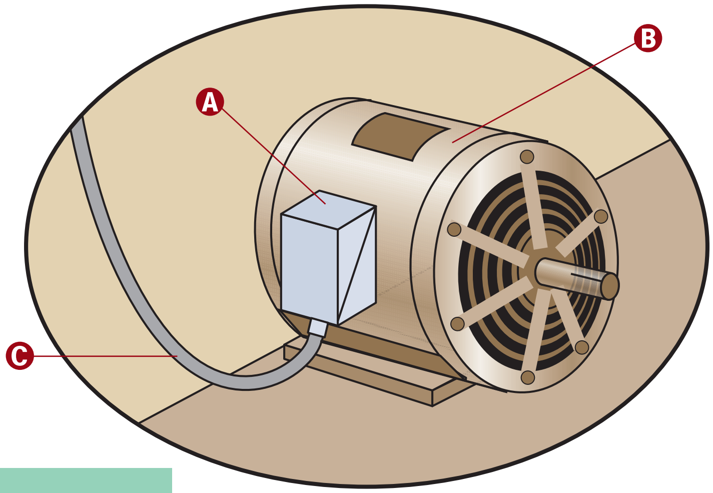
Motor Loads

Article 430 covers motors, motor branch-circuit and feeder conductors and their protection, motor overload protection, motor control circuits, motor controllers, and motor control centers »*430.1*«.

Ⓐ Loads for motor outlets shall be calculated in accordance with 430.22, 430.24, and 440.6 »*220.14(C)*«.

Ⓑ If a circuit supplies only motor-operated loads, apply Article 430 »*220.11(A)*«.

Ⓒ Branch-circuit conductors supplying a single motor, used in a continuous duty application, must have an ampacity of not less than 125% of the motor full-load current rating as determined by 430.6(A)(1), or not less than specified in 430.22(A) through (G) »*430.22*«.



Note

Conductors for a motor used in a short-time, intermittent, periodic, or varying-duty application must have an ampacity of not less than the percentage of the motor nameplate current rating shown in Table 430.22(E), unless the AHJ grants special permission for lower ampacity conductors »***430.22(E)***«.

Any motor application is considered continuous duty unless the nature of the apparatus driven is such that the motor will not operate continuously with load under any condition of use »***Note under Table 430.22(E)***«.

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Motor-Operated and Combination Loads

All appliances supplied by 50 volts or higher shall be listed »*422.6*«.

Ⓐ For circuits supplying loads consisting of motor-operated utilization equipment (fastened in place with a motor larger than ⅛ horsepower) in combination with other loads, the total calculated load must be based on 125% of the largest motor load plus the sum of the other loads »*220.11(A)*«.

Ⓑ Because equipment such as room air-conditioners, household refrigerators and freezers, drinking water coolers, and beverage dispensers are considered appliances, Article 422 provisions also apply.

Ⓒ For cord-and-plug- (or attachment fitting-) connected appliances, an accessible separable connector or an accessible plug (or attachment fitting) and receptacle combination shall be permitted to serve as the disconnecting means. The attachment fitting shall be a factory-installed part of the appliance and suitable for disconnection of the appliance. Where the separable connector or plug (or attachment fitting) and receptacle combination are not accessible, cord-and-plug-connected or attachment fitting-and-plug-connected appliances shall be provided with disconnecting means in accordance with 422.31 »*422.33(A)*«.

Ⓓ The rating of a receptacle or a separable connector must not be less than the rating of any connected appliance »*422.33(C)*«.

Ⓔ This is a branch circuit, consisting of two duplex receptacles.

Ⓕ If supplied by a 20-ampere circuit, this drinking fountain's maximum rating is 10 amperes (20 × 50%). If supplied by a 15-ampere circuit, the maximum rating is 7.5 (15 × 50%). In accordance with 422.5(A)(2), this receptacle outlet shall have ground-fault circuit-interrupter (GFCI) protection for personnel.

Ⓖ This is a receptacle outlet for cord- and plug-connected, non-fastened-in-place utilization equipment.

Ⓗ The receptacle outlet is fed from a dedicated branch circuit.

Ⓘ If supplied by a 20-ampere circuit, the maximum rating for this copy machine is 16 amperes (20 × 80%). If supplied by a 15-ampere circuit, the maximum rating is 12 amperes (15 × 80%).

Ⓙ For cord-connected equipment such as room air-conditioners, household refrigerators (and freezers), drinking water coolers, and beverage dispensers, a separable connector or an attachment plug and receptacle can serve as the disconnecting means »*440.13*«.

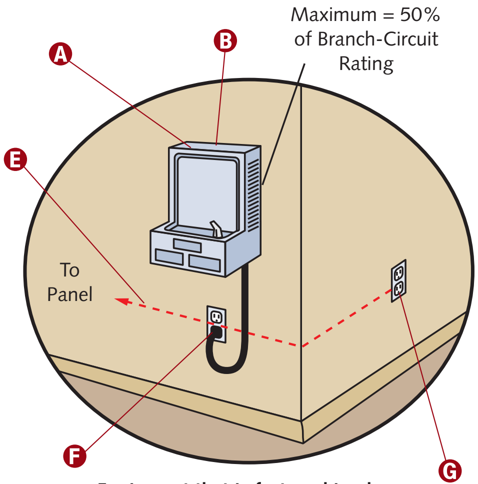
Note

A 15- or 20-ampere branch circuit can supply lighting units, other utilization equipment, or a combination of both. The rating of any one cord- and plug-connected utilization equipment that is not fastened in place must not exceed 80% of the branch-circuit ampere rating. The total rating of utilization equipment fastened in place (other than luminaires) cannot exceed 50% of the branch-circuit ampere rating in the event that lighting units, cord- and plug-connected utilization equipment not fastened in place, or both are also supplied »***210.23(B)***«.

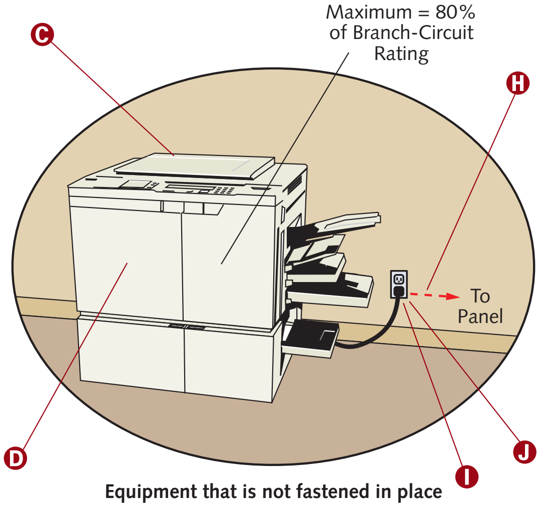
Caution

Electric drinking water coolers shall be protected with ground-fault circuit-interrupter protection » *210.8(D)(2)* and *422.5(A)(2)*«.

The GFCI shall be readily accessible, listed, and located in one or more of the following locations: (1) within the branch circuit overcurrent device, (2) a device or outlet within the supply circuit, (3) an integral part of the attachment plug, (4) within the supply cord not more than 12 in. (300 mm) from the attachment plug, and (5) factory installed within the appliance »*422.5(B)*«.



Equipment that is fastened in place



Equipment that is not fastened in place

Air-Conditioning and Refrigeration Equipment

Article 440, Part II, provisions require a means capable of disconnecting air-conditioning and refrigerating equipment (including motor compressors and controllers) from the circuit conductors »*440.11*«.

The provisions of Article 440, Part III, specify devices intended to protect the branch-circuit conductors, control apparatus, and motors in circuits supplying hermetic

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Air-Conditioning and Refrigeration Equipment *(continued)*

refrigerant motor compressors against overcurrent due to short circuits and ground faults. These provisions are in addition to or amendatory of the overcurrent protection requirements found elsewhere in the Code »*440.21*«.

Article 310 and Article 440, Part IV, provisions specify conductor ampacities required to carry the motor current (without overheating) under the conditions specified, except as modified in 440.6(A), Exception No. 1 »*440.31*«.

Article 440, Part VI, specifies devices intended to protect the motor compressor, the motor-control apparatus, and the branch-circuit conductors against excessive heating due to motor overload and failure to start »*440.51*«.

A Loads for motor outlets shall be calculated in accordance with the requirements in 430.22, 430.24, and 440.6 »*220.14(C)*«.

B Where a circuit supplies only air-conditioning equipment, refrigeration equipment, or both, apply Article 440 »*220.11(A)*«.

C Disconnecting means must be located within sight and readily accessible from the air-conditioning or refrigerating equipment. The disconnecting means can be installed on or within the equipment »*440.14*«.

D For a hermetic refrigerant motor compressor, the rated-load current marked on the nameplate of the equipment in which the motor compressor is employed must be used in determining the rating or ampacity of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground-fault protection, and the separate motor overload protection. Where no rated-load current is shown on the equipment nameplate, use the rated-load current shown on the compressor nameplate »*440.6(A)*«.

E Article 440 provisions apply to electric motor-driven air-conditioning and refrigerating equipment, and to their branch circuits and controllers. It provides the special considerations necessary for circuits supplying hermetic refrigerant motor compressors and for any air-conditioning or refrigerating equipment supplied from a branch circuit that also supplies a hermetic refrigeration motor compressor »*440.1*«.

Caution

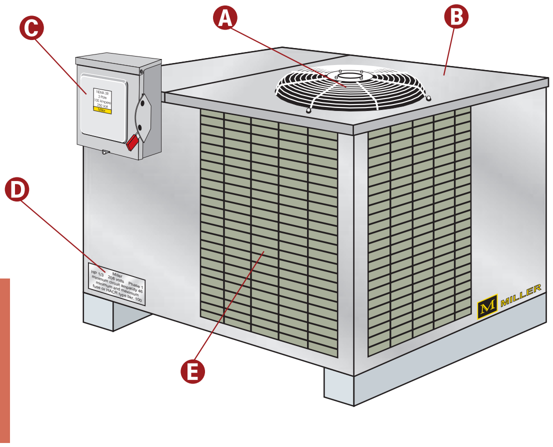
The disconnecting means must not be located on panels that are designed to allow access to the air-conditioning or refrigeration equipment or to obscure the equipment name plate(s). The working space requirements of 110.26(A) must be met »*440.14*«.

Note

A 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed at an accessible location for the servicing of heating, air-conditioning, and refrigeration equipment. The receptacle shall be located on the same level and within 25 ft (7.5 m) of the heating, air-conditioning, and refrigeration equipment. The receptacle outlet shall not be connected to the load side of the equipment's branch-circuit disconnecting means ***»210.63«***.

Note

All 125- through 250-volt single-phase receptacles rated 150 volts or less to ground having a rating of 50 amperes or less, as well as all three-phase receptacles rated 150 volts or less to ground having a rating of 100 amperes or less installed in the following locations shall have ground-fault circuit-interrupter protection for personnel ***»210.8(B)«***. The ground-fault circuit-interrupter shall be installed in a readily accessible location ***»210.8«***. Receptacles on rooftops shall not be required to be readily accessible other than from the rooftop ***»210.8(B) Exception No. 2«***.



Receptacles

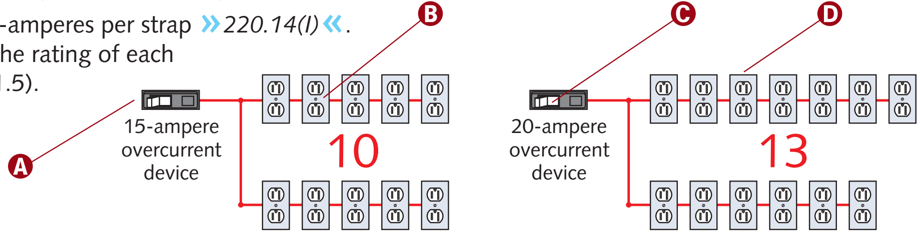
Maximum Number of Receptacles on a Branch Circuit

A Ten receptacles are permitted on a 15-ampere overcurrent protective device (15 ÷ 1.5 = 10).

B Receptacles are calculated at 180 volt-amperes per strap »*220.14(I)*«. Therefore, when the source is 120 volts, the rating of each receptacle is 1.5 amperes (180 ÷ 120 = 1.5).

C Thirteen receptacles are permitted on a 20-ampere overcurrent protective device (20 ÷ 1.5 = 13.3 or 13).

D A load having the maximum level of current sustained for three hours or more is referred to as a continuous load »*Article 100*«. A general purpose receptacle is not a continuous load.



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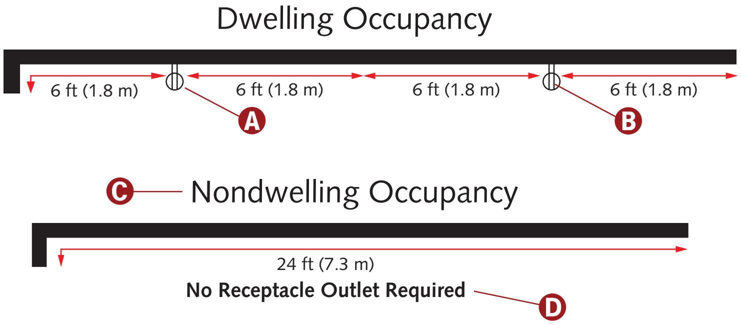
Nondwelling Receptacle Placement

A Dwelling unit receptacles must be installed so that no point along the floor line in any wall space is more than 6 ft (1.8 m), measured horizontally, from a receptacle outlet in that space »*210.52(A)(1)*«.

B Receptacle outlets in hotels, motels, sleeping rooms in dormitories, and similar occupancy must be installed in accordance with 210.52(A) and (D). Guest rooms or guest suites provided with permanent provisions for cooking shall have receptacle outlets installed in accordance with all of the applicable rules in 210.52 »*210.60(A)*«.

C Although no provisions pertain to nondwelling general receptacle placement (except hotel and motel guest rooms and suites), certain requirements exist for specific occupancies or areas. Examples include but are not limited to show windows »*210.62*«; near equipment requiring servicing »*210.63*« meeting rooms »*210.65*«; and health care patient bed location and operating room receptacles »*517.18* and *19*«.

D Generally speaking, there are no specific receptacle placement provisions for the majority of nondwelling occupancies.



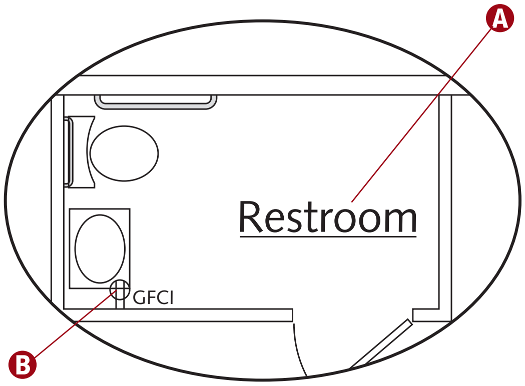
Bathroom Receptacles

A Most nondwelling bathrooms do not require receptacles. At least one bathroom receptacle is required in dwelling units, hotel or motel guest rooms, and sleeping rooms in dormitories »*210.52(D)* and *210.60(A)*«.

B Where installed, bathroom receptacles must have GFCI protection for personnel »*210.8(B)(1)*«.

Note

Class A GFCIs trip when the ground-fault current is 6 milliamps or higher and do not trip when the ground-fault current is less than 4 milliamps »***Article 100 Informational note under "Ground-Fault Circuit Interrupter (GFCI)"***«.



Caution

At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed at an accessible location within 25 ft (7.5 m) of the indoor electrical service equipment. The required receptacle outlet shall be located within the same room or area as the service equipment »*210.63*«.

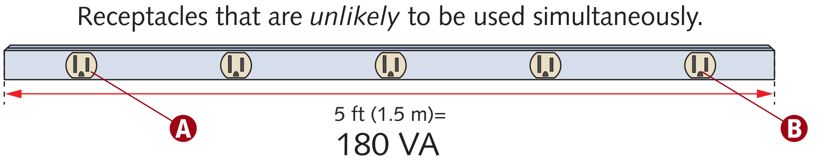
Fixed Multioutlet Assemblies

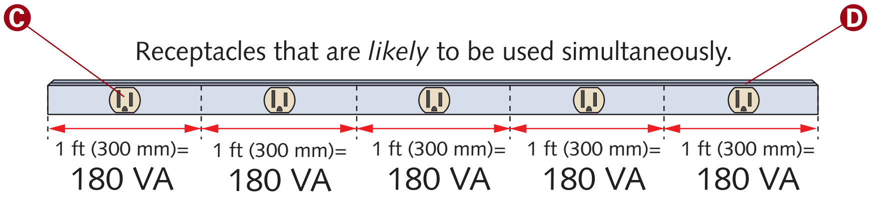
A Where appliances are unlikely to be used simultaneously, each 5 ft (1.5 m) or fraction thereof (of separate and continuous length) shall be considered one outlet of not less than 180 volt-amperes »*220.14(H)(1)*«.

B Because fixed multioutlet assemblies used in dwelling units or hotel and motel guest rooms and suites are included in the general lighting load calculation, no additional load calculation is required »*220.14(H)*«.

C Where appliances are likely to be used simultaneously, each 1 ft (300 mm) or fraction thereof shall be considered one outlet of not less than 180 volt-amperes »*220.14(H)(2)*«.

D It is not stipulated that each receptacle be rated 180 volt-amperes. This illustration shows one receptacle per foot; therefore, each receptacle is rated 180 volt-amperes. Multioutlet assemblies with two receptacles per ft (6 in. [150 mm] on center) have a rating of 180 volt-amperes for two receptacles.





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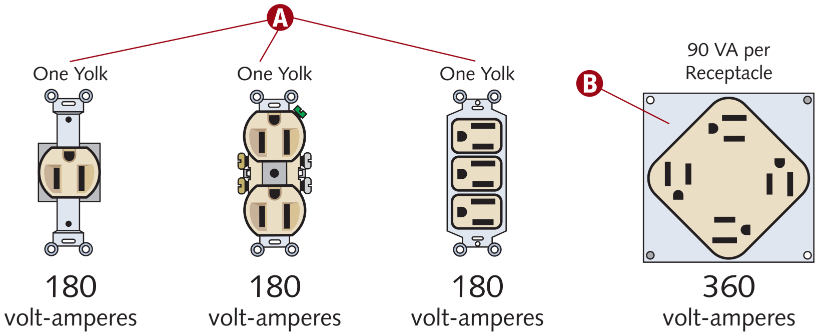
Receptacle Volt-Ampere Rating

A Except as covered in 220.41 and 220.14(J), receptacle outlets must be computed at not less than 180 volt-amperes for each single or multiple receptacle on one yoke »*220.14(I)*«.

B A single piece of equipment (consisting of four or more receptacles) must be calculated at not less than 90 volt-amperes per receptacle »*220.14(I)*«.



Provisions for Hotel and Motel Guest Rooms and Suites

When performing service (or feeder) calculations, use Table 220.45 to derate hotel and motel (include apartment houses without cooking equipment) guest room lighting and receptacle loads. Do not apply Table 220.45 demand factors to areas where all lighting will probably be used at one time. Examples include but are not limited to office, lobby, restaurant, hallway, and parking areas.

Note

Hotels, motels, and similar occupancies having guest kitchen facilities must meet all applicable provisions in 210.52 »*210.60(A)*«.

It is not required that occupants in hotel/motel guest rooms or suites that are intended for transient occupancy have ready access to all overcurrent devices protecting conductors supplying their room »*240.24(B)(1)*«.

Caution

Overcurrent protective devices (other than supplementary overcurrent protection) shall not be located in bathrooms, showering facilities, or locker rooms with showering facilities »*240.24(E)*«.

A GFCI protection is required for every 125-volt bathroom receptacle »*210.8(B)(1)*«.

B Hallways do not require a receptacle. Section 210.60(A) does not require guest rooms in hotels or motels to comply with 210.52(H) unless permanent provisions for cooking are provided.

C At least one lighting outlet controlled by a listed wall-mounted control device must be installed in every habitable room and bathroom in a guest room or suite of a hotel, motel, or similar occupancy. A receptacle controlled by a listed wall-mounted control device is permitted in lieu of a lighting outlet in other than bathrooms and kitchens »*210.70(B)*«.

D Receptacles must be installed so that no point along the floor line of any wall space is more than 6 ft (1.8 m), measured horizontally, from an outlet in that space »*210.52(A)(1)*«. (See 210.60(B) provisions allowing a greater distance due to permanent furniture layout.)

E Guest rooms or suites in hotels, motels, sleeping rooms in dormitories, and similar occupancies must have receptacle outlets installed in accordance with 210.52 (A) and (D) (dwelling unit receptacle provisions). If permanent provisions for cooking are installed, all applicable rules in 210.52 must be applied »*210.60(A)*«. (See Units 6 and 7 in this book for dwelling unit receptacle requirements.)

F Locate at least one wall receptacle within 36 in. (900 mm) of the outside edge of each sink. The receptacle outlet must be located on a wall or partition adjacent to the sink or sink countertop »*210.52(D)*«.

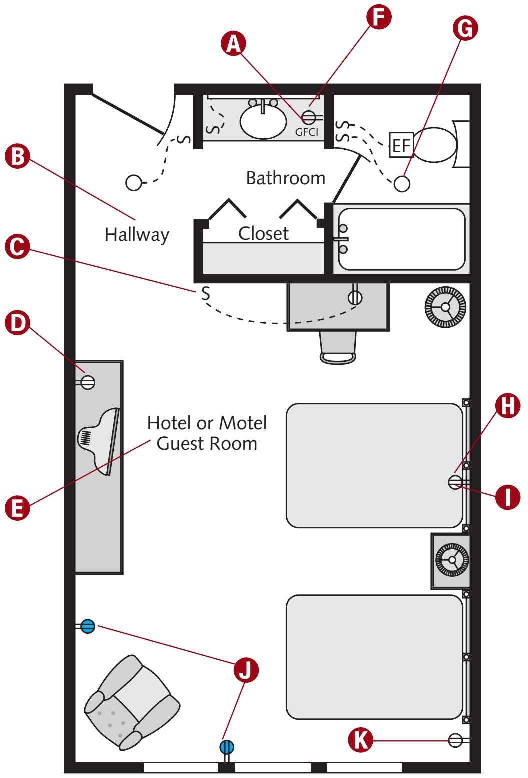
G Section 410.10(D) contains bathtub and shower area lighting provisions. (See the illustrated explanation in Unit 7 of this book.)

H Receptacles installed behind the bed must either be positioned so that the bed does not contact any installed attachment plug, or the receptacle must include a suitable guard »*210.60(B)*«.

I The total number of receptacle outlets must comply with the minimum number of receptacles provision of 210.52(A). These receptacle outlets can be located conveniently for permanent furniture layout »*210.60(B)*«. This receptacle could be located between the beds, even though the distance to the receptacle behind the desk exceeds 12 ft (3.7 m).

J At least two receptacle outlets must be readily accessible »*210.60(B)*«.

K Branch-circuit conductors supplying more than one receptacle for cord- and plug-connected portable loads must have an ampacity at least equal to the rating of the branch circuit »*210.19(B)*«.



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Show Windows

A *show window* is any window, including windows above doors, used or designed to be used for the display of goods or advertising material, whether it is fully or partly enclosed or entirely open at the rear, and whether or not it has a platform raised higher than the street floor level »*Article 100*«.

Unless used in wiring of chain-supported luminaires, or as supply cords for portable lamps and other merchandise being displayed or exhibited, flexible cords used in showcases and show windows must be Type S, SE, SEO, SEOO, SJ, SJE, SJEO, SJEOO, SJO, SJOO, SJT, SJTO, SJTOO, SO, SOO, ST, STO, STOO, SEW, SEOW, SEOOW, SJEW, SJEOW, SJEOOW, SJOW, SJOOW, SJTW, SJTOW, SJTOOW, SOW, SOOW, STW, STOW, or STOOW »*400.15*«.

A Show-window branch-circuit loads must be calculated either by (1) the unit load per outlet as required by other provisions of 220.14 or (2) at 200 volt-amperes per linear foot »*220.14(G)*«.

B At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed within 18 in. (450 mm) of the top of each show window. No point along the top of the window shall be farther than 6 ft (1.8 m) from a receptacle outlet »*210.62*«.

C The second method for calculating show-window branch-circuit loads is to multiply each show-window linear foot by 200 volt-amperes (2 + 11.5 + 2 = 15.5 = 15 linear ft . . . 15 × 200 = 3000 volt-amperes) »*220.14(G)*«.

D One of two methods for calculating show-window branch-circuit loads is to multiply each receptacle by 180 volt-amperes (180 × 3 = 540 volt-amperes) »*220.14(G) and (I)*«.

E Complete show-window feeder and/or service loads using a minimum rating of 200 volt-amperes for each linear ft of window, measured horizontally along its base (15 × 200 = 3000 volt-amperes) »*220.46(A)*«.

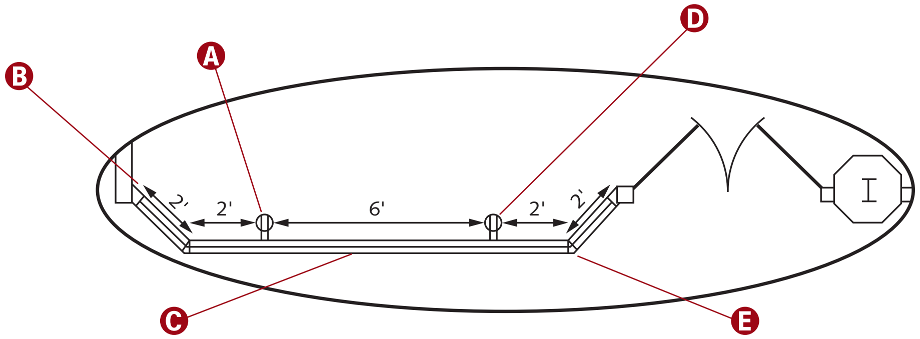
Caution

Where receptacles are installed in the floor, the boxes that house the receptacles must be listed specifically for the application »*314.27(B)*«.

Note

Where the AHJ judges them free from likely exposure to physical damage, moisture, and dirt, boxes located in elevated floors of show windows and similar locations can be other than those listed for floor applications. Receptacles and covers must be listed as an assembly for this type of location »***314.27(B) Exception***«.

Electric signs (including neon tubing) and associated wiring within show windows must comply with Article 600.



Lighting

Lampholder Installations

A Lampholders of the screw shell type shall be installed for use as lampholders only »*410.90*«.

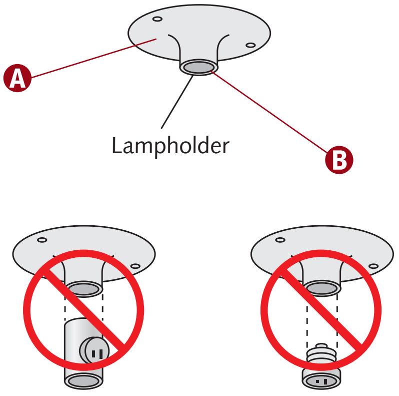
B If the supply circuit has a grounded conductor, the grounded conductor must be connected to the screw shell »*410.90*«.

Note

Lampholders installed in wet locations shall be listed for use in wet locations. Lampholders installed in damp locations shall be listed for damp locations or shall be listed for wet locations »***410.96***«.

Warning

Lampholders shall be constructed, installed, or equipped with shades or guards so that combustible material is not subjected to temperatures in excess of 90°C (194°F) »*410.97*«.



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Reflective Ceiling/Lighting Plan

Branch circuits recognized by Article 210 must be rated in accordance with the maximum permitted overcurrent device ampere rating (or setting) »*210.18*«.

Branch circuits for lighting and appliances (including motor-operated appliances) shall be provided to supply the loads calculated in accordance with 220.10 »*210.11*«.

A 15- or 20-ampere branch circuit can supply lighting units or other utilization equipment, or a combination of both »*210.23(B)*«.

Wall switch–controlled lighting outlets are not required in commercial occupancies other than hotels and motels, except for attics and underfloor spaces, utility rooms, and basements, where these spaces are used for storage or contain equipment requiring servicing »*210.70(C)*«.

A unit load meeting Table 220.42(A) specifications for nondwelling occupancies constitutes the minimum lighting load for each square foot of floor area. The area for each floor must be calculated using the outside dimensions of the building, dwelling unit, or other area involved »*220.5(C)* and *220.42(A)*«.

Supplementary overcurrent protection used for luminaires, appliances, and other equipment (including internal circuits and components) must not be used as a substitute for required branch-circuit overcurrent devices or in place of the branch-circuit protection. Ready accessibility is not required for supplementary overcurrent devices »*240.10*«.

Note

Luminaire is a complete lighting unit consisting of a light source such as a lamp or lamps, together with the parts designed to position the light source and connect it to the power supply. It may also include parts to protect the light source or the ballast or to distribute the light. A lampholder itself is not a luminaire »***Article 100***«.

A 30-, 40-, or 50-ampere branch circuit can supply fixed lighting units with heavy-duty lampholders in other than dwelling unit(s) »*210.23(C)* and *(D)*«.

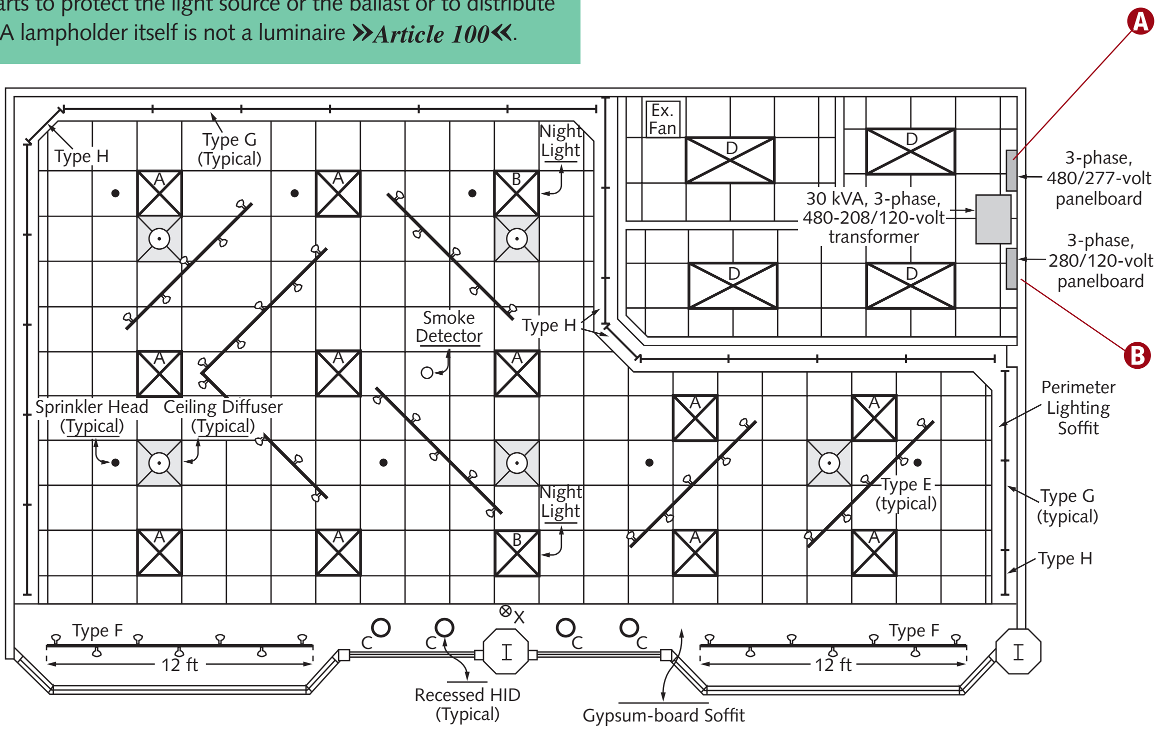
Lighting outlet loads must not be supplied by branch circuits larger than 50 amperes »*210.23(E)*«.

Ⓐ For circuits of over 250 volts to ground, the electrical continuity of metal raceways and cables with metal sheaths containing any conductor other than service conductors shall be ensured by one or more of the methods specified for services in 250.92(B) except for (B)(1) »*250.97*«.

Ⓑ Circuit breakers used as switches in 120-volt and 277-volt fluorescent lighting circuits shall be listed and shall be marked SWD or HID »*240.83(D)*«. Excluding limited exceptions, all switches and circuit breakers used as switches must be located so that they are operable from a readily accessible place. The center of the operating-handle grip of the switch or circuit breaker when in its highest position must not be more than 6 ft, 7 in. (2.0 m) above the floor or working platform »*404.8(A)*«.

Caution

Wiring located within the cavity of a floor–ceiling or roof–ceiling assembly shall not be secured to, or supported by, the ceiling assembly, including the ceiling support wires. An independent means of secure support shall be provided and shall be permitted to be attached to the assembly. Where independent support wires are used, they shall be distinguishable by color, tagging, or other effective means »*300.11(B)(1)* and *(2)*«.



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Luminaire Schedule

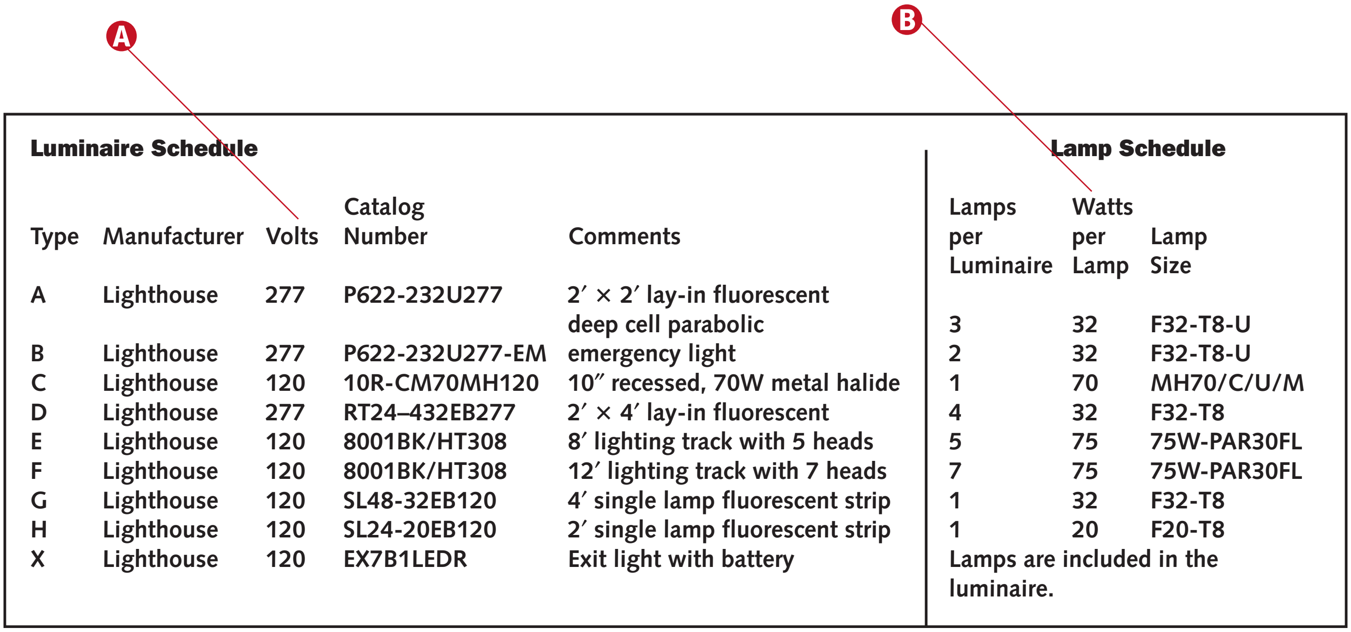
The minimum number of branch circuits is determined from the total calculated load and the size (or rating) of the circuits used. In all installations, the number of circuits must be sufficient to supply the load served. In no case shall the load on any circuit exceed the maximum specified by 220.11 »*210.11(A)*«.

The load calculated on a volt-ampere per square-foot (or per square-meter) basis must be adequately served by the wiring system up to and including the branch-circuit panelboard(s). This load must be evenly proportioned among multioutlet branch circuits within the panelboard(s). Branch circuits and overcurrent devices must only be installed to serve the connected load »*210.11(B)*«.

Ⓐ Conductors of alternating-current (ac) and direct-current (dc) circuits, rated 1000 volts ac, 1500 volts dc, nominal or less, can occupy the same equipment wiring enclosure, cable, or raceway. The conductors' insulation rating must equal or exceed the maximum circuit voltage applied to any conductor within the enclosure, cable, or raceway.

Secondary wiring to electric-discharge lamps of 1000 volts ac, 1500 volts dc, or less, if insulated for the secondary voltage involved, shall be permitted to occupy the same luminaire, sign, or outline lighting enclosure as the branch-circuit conductors »*300.3(C)(1)*«.

Ⓑ For lighting units that have ballasts, transformers, or autotransformers or LED drivers, the supply circuit's calculated load is based on the total ampere ratings of such units, not on the lamps' total wattage »*220.11(B)*«. Obtain the ampere rating from the manufacturer or from the information listed on the ballast. If the luminaire contains more than one ballast, add the ampere ratings. Multiply the total ampere rating by the voltage to find the luminaire's volt-ampere rating.



Luminaire Schedule

Type	Manufacturer	Volts	Catalog Number	Comments
A	Lighthouse	277	P622-232U277	2′ × 2′ lay-in fluorescent deep cell parabolic
B	Lighthouse	277	P622-232U277-EM	emergency light
C	Lighthouse	120	10R-CM70MH120	10″ recessed, 70W metal halide
D	Lighthouse	277	RT24–432EB277	2′ × 4′ lay-in fluorescent
E	Lighthouse	120	8001BK/HT308	8′ lighting track with 5 heads
F	Lighthouse	120	8001BK/HT308	12′ lighting track with 7 heads
G	Lighthouse	120	SL48-32EB120	4′ single lamp fluorescent strip
H	Lighthouse	120	SL24-20EB120	2′ single lamp fluorescent strip
X	Lighthouse	120	EX7B1LEDR	Exit light with battery

Lamp Schedule

Lamps per Luminaire	Watts per Lamp	Lamp Size
3	32	F32-T8-U
2	32	F32-T8-U
1	70	MH70/C/U/M
4	32	F32-T8
5	75	75W-PAR30FL
7	75	75W-PAR30FL
1	32	F32-T8
1	20	F20-T8

Lamps are included in the luminaire.

Note

Branch-circuit conductors shall have an ampacity not less than the maximum load to be served. Conductors shall be sized to carry not less than the larger of 210.19(A)(1)(1) or (2).

(1) Where a branch circuit supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum branch-circuit conductor size shall have an allowable ampacity not less than the noncontinuous load plus 125% of the continuous load.

(2) The minimum branch-circuit conductor size shall have an allowable ampacity not less than the maximum load to be served after the application of any adjustment or correction factors »*210.19(A)*«.

Most commercial lighting is considered continuous.

Caution

Luminaires installed in exposed or concealed locations under metal-corrugated sheet roof decking where subject to physical damage shall be installed and supported so there is not less than 1½ in. (38 mm) measured from the lowest surface of the roof decking to the top of the luminaire unless the metal-corrugated roof decking is covered with a minimum of 2 in. of concrete »*410.10(10)(F)* and *Exception*«.

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Fluorescent Luminaires

Luminaires shall be equipped with shades (or guards) and constructed or installed so that combustible material will not be subjected to temperatures exceeding 90°C (194°F) »*410.11*«.

Securely support all luminaires and lampholders »*410.30(A)*«.

Exposed conductive surfaces shall be connected to an equipment grounding conductor unless: (1) Surfaces are separated from all live parts by a listed system of double insulation; (2) surfaces are on small isolated parts, such as mounting screws, clips, and decorative bands on glass spaced at least 1½ in. (38 mm) from lamp terminals; or (3) surfaces are on portable luminaires with a polarized attachment plug »*410.42* and *Exception*«.

Raceway fittings supporting a luminaire(s) shall be capable of supporting the combined weight of the luminaire assembly and lamp(s) »*410.36(E)*«.

Ⓐ Suspended-ceiling system framing members used to support luminaires must be securely fastened to each other and to the building structure at appropriate intervals. Luminaires must be fastened securely to the ceiling framing member by mechanical means such as bolts, screws, or rivets. Listed clips identified for use with the type of ceiling framing member(s) and luminaire(s) are also permitted »*410.36(B)*«.

Ⓑ Branch circuits recognized by Article 210 can be used as multiwire circuits. A multiwire branch circuit can be thought of as multiple circuits. All conductors must originate from the equipment containing the branch-circuit overcurrent protective device(s) »*210.4(A)*«. Unless an exception is met, multiwire branch circuits can only supply line-to-neutral loads »*210.4(C)*«.

Ⓒ A 3-phase, 4-wire, wye-connected power system supplying nonlinear loads may necessitate a design allowing for the possibility of high harmonic neutral currents on the neutral conductor »*210.4(A) Informational Note No. 1*«.

Warning

Where more than one neutral conductor associated with different circuits is in an enclosure, grounded circuit conductors of each circuit shall be identified or grouped to correspond with the ungrounded circuit conductor(s) by wire markers, cable ties, or similar means in at least one location within the enclosure unless meeting one of the two exceptions »*200.4(B)*«.

Ⓓ Luminaires and equipment that require connection to an equipment grounding conductor in accordance with 410.42 must be mechanically connected to an equipment grounding conductor unless one of the two exceptions can be applied »*410.44*«.

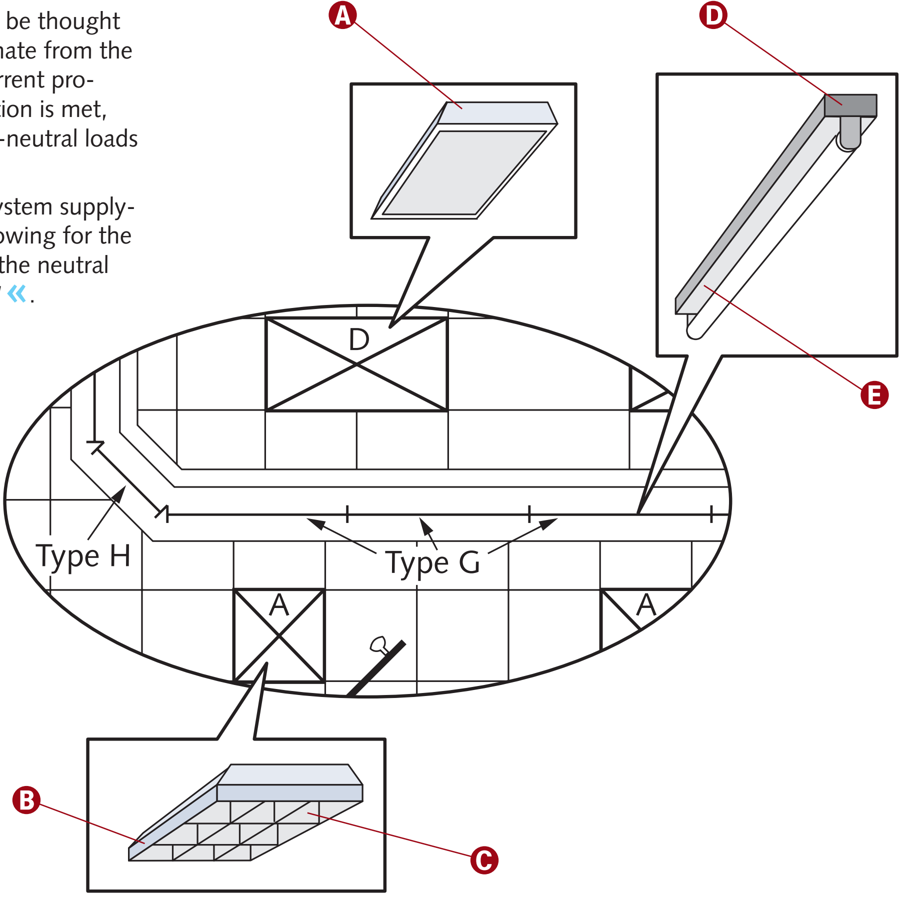
Ⓔ Wiring on or within luminaires must be neatly arranged and must not be exposed to physical damage. Avoid excess wiring. Arrange conductors so they are not subjected to temperatures greater than those for which they are rated »*410.50*«.

Note

Install luminaires so that the connections between luminaire conductors and circuit conductors can be inspected without having to disconnect any of the wiring, unless the luminaires are connected by attachment plugs and receptacles »***410.8***«.

Caution

Each multiwire branch circuit shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point where the branch circuit originates »*210.4(B)*«.



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Show-Window and Track Lighting

Heavy-duty lighting track is identified for use exceeding 20 amperes. Each fitting attached to a heavy-duty lighting track shall have individual overcurrent protection »*410.153*«.

A Lighting track (track lighting) is a manufactured assembly designed to support and energize luminaires that are capable of being readily repositioned along the track. Its length may be altered by the addition or subtraction of track sections »*Article 100*«.

B Lighting track shall be permanently installed as well as permanently connected to a branch circuit. Install only lighting track fittings on the lighting track. Fittings equipped with general-purpose receptacles shall not be used on lighting track »*410.150(A)*«.

C Lighting track shall be securely mounted so that each fastening suitably supports the maximum weight of luminaires that can be installed. Unless identified for greater support intervals, a single section 4 ft (1.2 m) or less in length shall have two supports. If installed in a continuous row, each individual section of not more than 4 ft (1.2 m) in length shall have one additional support »*410.154*«.

D Lighting track shall be grounded in accordance with Part V of Article 410. Track sections shall be securely coupled to maintain continuity of the circuitry, polarization, and grounding throughout »*410.155(B)*«.

E Track system ends shall be insulated and capped »*410.155(A)*«.

F The load connected to a lighting track shall not exceed the track's rating. The rating of the branch circuit that supplies lighting track shall not exceed the track rating. The load calculation in 220.46(B) shall not be required to limit the length of track on a single branch circuit, and it shall not be required to limit the number of luminaires on a single track »*410.150(B)*«.

G Fittings identified for use on lighting track shall be designed specifically for the track on which they are installed. They shall be securely fastened to the track, maintain polarization and connection to the equipment grounding conductor, and be designed to be suspended directly from the track »*410.150(D)*«.

H When computing feeder or service track lighting in nondwelling units include an additional load of 150 volt-amperes for every 2 ft (600 mm) of lighting track or fraction thereof »*220.46(B)*«.

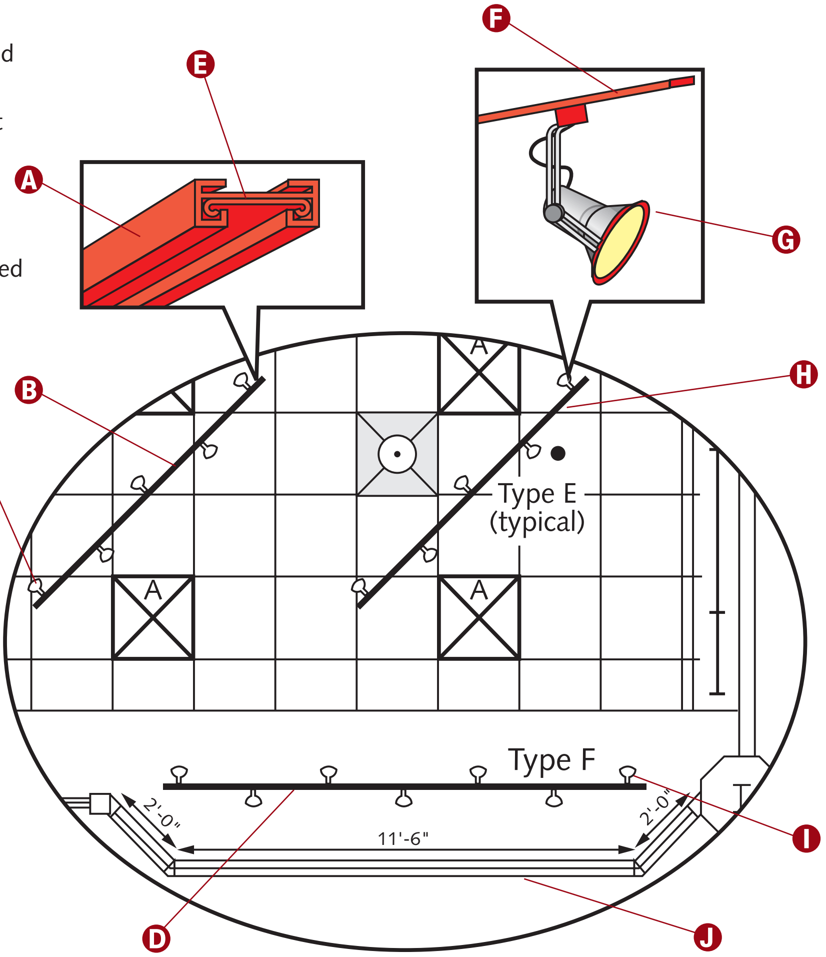
I No externally wired luminaire except chain-supported shall be used in show windows »*410.14*«.

J When calculating feeder or service show-window lighting, include a unit load of not less than 200 volt-amperes per linear foot of show window, measured horizontally along the base »*220.46(A)*«
(2 + 11.5 + 2 = 15.5 = 15 × 200 = 3000 volt-amperes).

Note

Do not install lighting track in the following locations:

1. Where physical damage is likely
2. In wet or damp locations
3. Where subject to corrosive vapors
4. In storage battery rooms
5. In hazardous (classified) locations
6. Where concealed
7. Where extended through walls or partitions
8. Less than 5 ft (1.5 m) above the finished floor except where protected from physical damage or where the track operates at less than 30 volts root-mean-square (rms) open-circuit voltage
9. Where prohibited by 410.10(D) »**410.150(C)**«.



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Recessed Luminaires

A recessed luminaire not identified for contact with insulation shall have all recessed parts spaced at least ½ in. (13 mm) from combustible materials. Support points and the trim finishing off the openings in the ceiling, wall, or other finished surface can be in contact with combustible materials »*410.116(A)(1)*«.

A recessed luminaire identified for contact with insulation, Type IC, can contact combustible materials at recessed parts, points of support, and portions passing through or finishing off the structural opening »*410.116(A)(2)*«.

A recessed HID luminaire identified for use and installed in poured concrete does not require thermal protection »*410.130(F)(3)*«.

Ⓐ A luminaire can be recessed in fire-resistant material in a building of fire-resistant construction if (1) the recessed luminaire is listed for use in a fire resistance-rated construction; or (2) the recessed luminaire is installed in or used with a luminaire enclosure that is listed for use in a fire resistance-rated construction; or (3) the recessed luminaire is listed and installed in accordance with a tested fire resistance-rated assembly »*410.116(C)*«.

Ⓑ Install luminaires so that adjacent combustible material will not be subjected to temperatures greater than 90°C (194°F) »*410.115(A)*«.

Ⓒ Luminaires installed in recessed cavities in walls or ceilings, including suspended ceilings, shall comply with 410.115 through 410.126 »*410.110*«.

Ⓓ Thermal insulation shall not be installed above a recessed luminaire or within 3 in. (75 mm) of the recessed luminaire's enclosure, wiring compartment, ballast, transformer, LED driver, or power supply unless the luminaire is identified as Type IC for insulation contact »*410.116(B)*«.

Ⓔ High-intensity discharge (HID) luminaires supply power to HID lamps. HID lamps produce light from gaseous discharge arc tubes and include mercury lamps, metal halide lamps, and high-pressure sodium lamps.

Ⓕ A recessed remote ballast for a HID luminaire shall have integral thermal protection and be identified as such »*410.130(F)(4)*«.

Note

HID luminaires are commonly converted to LED fixtures. All LED retrofit kits must be listed »*410.6*«.

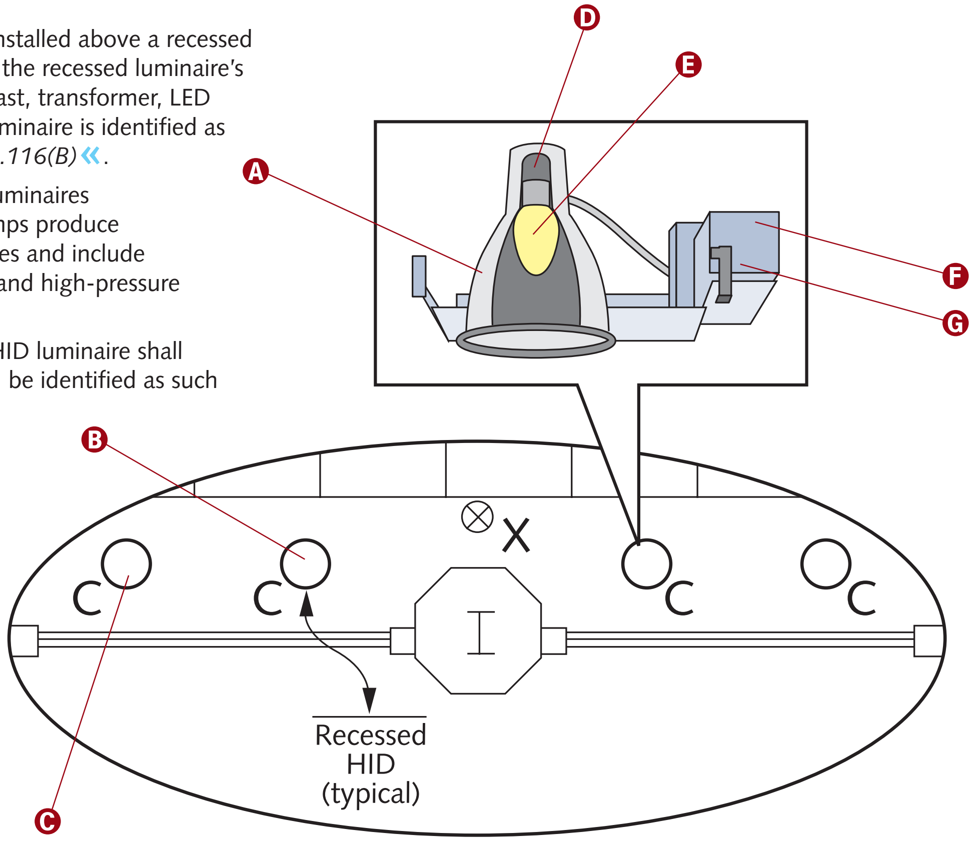
Ⓖ Recessed high-intensity luminaires designed for installations in wall or ceiling cavities shall have thermal protection and be identified as such »*410.130(F)(1)*«. Thermal protection is not required in a recessed high-intensity luminaire whose design, construction, and thermal performance characteristics are equivalent to a thermally protected luminaire and are identified as inherently protected »*410.130(F)(2)*«.

Note

Luminaires that have exposed ballasts, transformers, LED drivers, or power supplies shall be installed such that ballasts, transformers, LED drivers, or power supplies shall not be in contact with combustible material unless listed for such condition »*410.136(A)*«.

Warning

Circuit breakers used as switches in 120-volt and 277-volt fluorescent lighting circuits shall be listed and shall be marked SWD or HID. Circuit breakers used as switches in high-intensity discharge lighting circuits shall be listed and shall be marked as HID »*240.83(D)*«.



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Exit Luminaires and Egress Luminaires

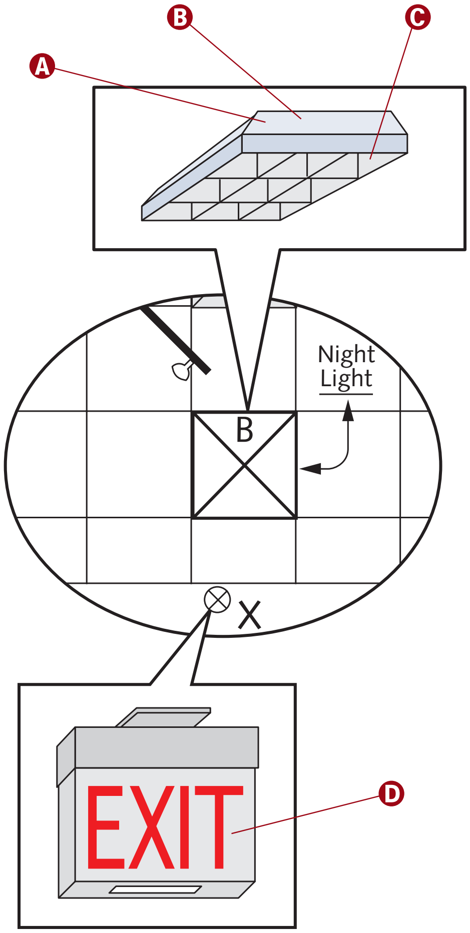
A ballast in a fluorescent exit luminaire shall not have thermal protection »*410.130(E)(3)*«.

A Framing members of suspended ceiling systems used to support luminaires shall be securely fastened to each other and to the building structure at appropriate intervals. Luminaires shall be securely fastened to the ceiling framing member by mechanical means such as bolts, screws, or rivets. Listed clips identified for use with the type of ceiling framing member(s) and luminaires are also permitted »*410.36(B)*«.

B The ballast of a fluorescent luminaire installed indoors shall have integral thermal protection. Replacement ballasts shall also have thermal protection integral with the ballast »*410.130(E)(1)*«.

C A fluorescent luminaire ballast used for egress lighting, energized only during a failure of the normal supply, shall not have thermal protection »*410.130(E)(4)*«.

D An exit directional sign located within a building does not require a disconnecting means »*600.6 Exception No. 1*«.



Note

Article 700 provisions apply to the electrical safety of emergency systems installation, operation, and maintenance. These systems consist of circuits and equipment intended to supply, distribute, and control electricity for facility illumination, power, or both whenever the normal electrical service is interrupted »***700.1***«. Emergency systems are defined as those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction. The purpose of these systems is to automatically supply illumination, power, or both to designated areas and equipment in the event of failure of the normal supply, or in the event of accidental damage to systems elements intended to supply, distribute, and control power and illumination essential for safety to human life »***Article 100***«.

Adjustable Luminaires

A Two conduits can support an enclosure containing a device under the conditions found in 314.23(F): (1) the box shall not exceed 100 in.^{3} (1650 cm^3); (2) the box has either threaded entries or identified hubs; (3) the box must be supported by two or more conduits threaded wrenchtight into the enclosure or hubs; and (4) each conduit must be secured within 18 in. (450 mm) of the enclosure.

B Equipment grounding conductors that are part of flexible cords with the largest circuit conductor 10 AWG or smaller or used with luminaire wires in accordance with 240.5 shall not be smaller than 18 AWG copper and not smaller than the circuit conductors »*250.122(E)*«.

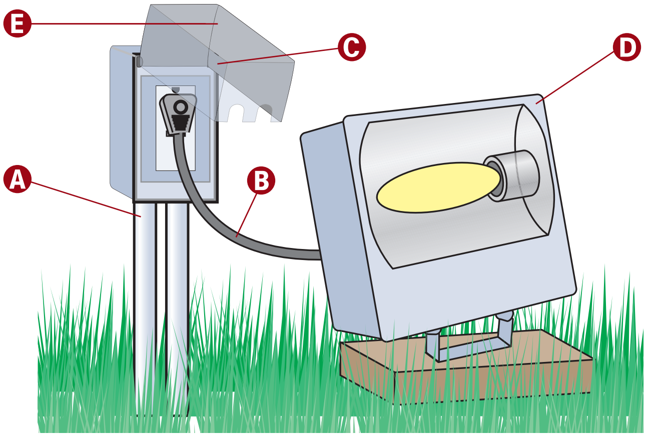
C Receptacles of 15 and 20 amperes, 125 and 250 volts installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed and shall be identified as "extra-duty" »*406.9(B)(1)*«.

D Luminaires that require adjusting or aiming after installation do not require an attachment plug or cord connector, provided the exposed cord is suitable for hard or extra-hard usage and is not longer than that required for maximum adjustment. The cord shall not be subject to strain or physical damage »*410.62(B)*«.

E Hinged covers of outlet box hoods shall be able to open at least 90 degrees or fully open if the cover is not designed to open 90 degrees from the closed to open position after installation »*406.9(B)(1)*«.

Note

Other listed products, enclosures, or assemblies providing weatherproof protection that do not utilize an outlet box hood need not be identified as "extra duty" »***406.9(B)(1)***«.



Caution

All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles in damp or wet locations be listed and so identified as the weather-resistant type »*406.9(A)* and *(B)(1)*«.

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Switches Controlling Lighting Loads

The grounded circuit conductor for the controlled lighting circuit shall be installed at the location where switches control lighting loads that are supplied by a grounded general-purpose branch circuit serving bathrooms, hallways, stairways, and habitable rooms or occupiable spaces as defined in the applicable building code. Where multiple switch locations control the same lighting load such that the entire floor area of the room or space is visible from the single or combined switch locations, the grounded circuit conductor shall only be required at one location. A grounded conductor shall not be required to be installed at lighting switch locations under any of the following conditions:

(1) Where conductors enter the box enclosing the switch through a raceway, provided that the raceway is large enough for all contained conductors, including a grounded conductor

(2) Where snap switches with integral enclosures comply with 300.15(E)

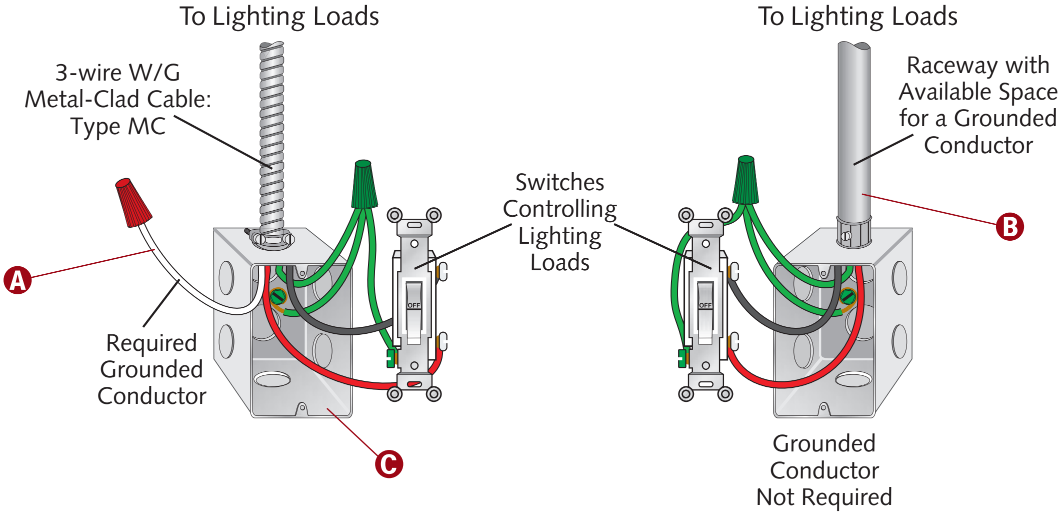
(3) Where lighting in the area is controlled by automatic means

(4) Where a switch controls a receptacle load »*404.2(C)*«.

A Because this switch is supplied by an MC cable, a grounded conductor is required.

B Because the conductors enter the box through a raceway and the raceway is large enough for all contained conductors, including a grounded conductor, a grounded conductor is not required.

C The provision for a (future) grounded conductor is to complete a circuit path for electronic lighting control devices »*404.2(C) Informational Note*«.


To Lighting Loads
3-wire W/G Metal-Clad Cable: Type MC
A
Required Grounded Conductor
C
Switches Controlling Lighting Loads
To Lighting Loads
Raceway with Available Space for a Grounded Conductor
B
Grounded Conductor Not Required
OFF
OFF

Luminaires Used as Raceways

In a completed installation, a cover shall be provided for each outlet box, unless covered by means of a luminaire canopy, lampholder, receptacle, or similar device »*410.22*«.

Auxiliary equipment for electric-discharge lamps shall be enclosed in noncombustible cases and be treated as heat sources »*410.104(A)*«.

A Luminaires designed for end-to-end connection, thereby forming a continuous assembly, or luminaires connected by recognized wiring methods, are permitted to contain the conductors of a 2-wire branch circuit or one multiwire branch circuit supplying the connected luminaires and need not be listed as a raceway »*410.64(C)*«.

B One additional 2-wire branch circuit separately supplying one or more of the connected luminaires is also permitted »*410.64(C)*«.

C Feeder and branch-circuit conductors within 3 in. (75 mm) of a ballast, LED driver, power supply, or transformer shall have an insulation temperature rating no lower than 90°C (194°F) unless supplying a luminaire marked as suitable for a different insulation temperature »*410.68*«.

D Luminaires shall not be used as a raceway for circuit conductors unless listed and marked for use as a raceway »*410.64* and *410.64(A)*«.

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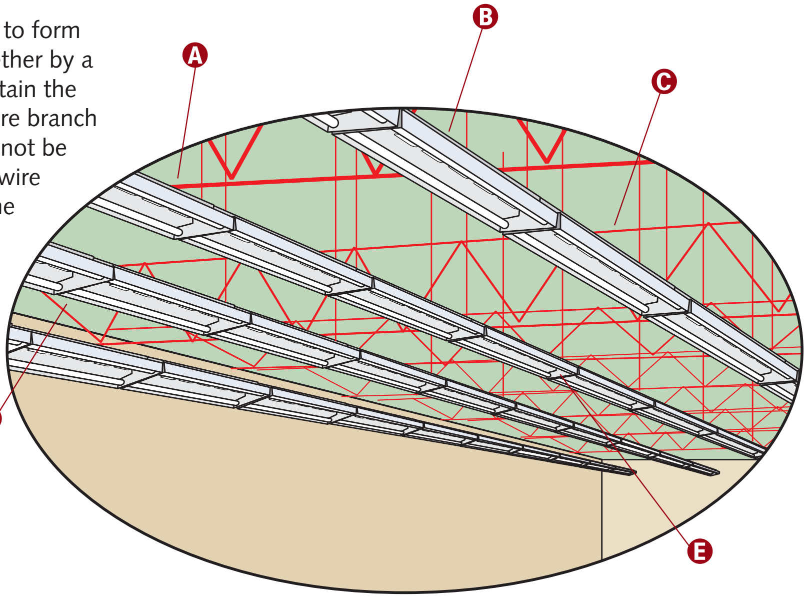
Luminaires Used as Raceways *(continued)*

E Luminaires identified for through-wiring, as permitted by 410.21, shall be permitted to be used as a raceway »*410.64(B)*«.

Luminaires designed for end-to-end connection to form a continuous assembly, or luminaires connected together by a recognized wiring method, shall be permitted to contain the conductors of a 2-wire branch circuit, or one multiwire branch circuit, supplying the connected luminaires and shall not be required to be listed as a raceway. One additional 2-wire branch circuit separately supplying one or more of the connected luminaires shall also be permitted »*410.64(C)*«.

Note

Electric-discharge and LED luminaires supported independent of the outlet box shall be connected to the branch circuit through metal raceway, nonmetallic raceway, Type MC cable, Type AC cable, Type MI cable, or nonmetallic-sheathed cable, or by flexible cord as permitted in 410.62(B) or (C) ***»410.24(A)«***.



Cord-Connected Lampholders and Luminaires

The inlet of a metal lampholder attached to a flexible cord shall be equipped with an insulating bushing that, if threaded, is not smaller than nominal ⅜-in. pipe size. The cord hole shall be of an appropriate size, and all burrs/fins must be removed, providing a smooth bearing surface for the cord »*410.62(A)*«.

A Electric-discharge luminaires provided with mogul-base, screw shell lampholders can be connected to branch circuits of 50 amperes or less by cords that comply with 240.5. While receptacles and attachment plugs can be of a lower ampere rating than the branch circuit, they shall not be less than 125% of the luminaire full-load current »*410.62(C)(2)*«.

B A luminaire or a listed assembly in compliance with any of the conditions in 410.62(C)(1)(a) through (c) shall be permitted to be cord connected provided the luminaire is located directly below the outlet or busway, the cord is not subject to strain or physical damage, and the cord is visible over its entire length except at terminations.

(a) A luminaire shall be permitted to be connected with a cord terminating in a grounding-type attachment plug or busway plug. If grounding is not required in accordance with 410.42, a polarized-type plug shall be permitted.

(b) A luminaire assembly equipped with a strain relief and canopy shall be permitted to use a cord connection between the luminaire assembly and the canopy. The canopy shall be permitted to include a section of raceway not over 6 in. (150 mm) in length and intended to facilitate the connection to an outlet box mounted above a suspended ceiling.

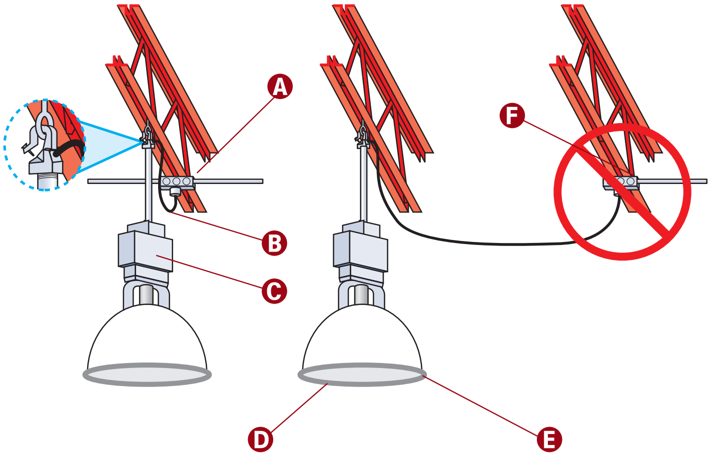
(c) Listed luminaires connected using listed assemblies that incorporate manufactured wiring system connectors in accordance with 604.100(C) shall be permitted to be cord connected »*410.62(C)(1)*«.

C For circuits that supply lighting units with ballasts, transformers, autotransformers, or LED drivers, the computed load shall be based on the total ampere rating of such units and not on the total lamp(s) wattage »*220.11(B)*«.

D A load expected to continue at maximum current for 3 hours or more is a continuous load »*Article 100*«.

E Electric-discharge luminaires having a flanged surface inlet can be supplied by cord pendants equipped with cord connectors. Inlets and connectors can be of a lower ampere rating than the branch circuit but not less than 125% of the luminaire load current »*410.62(C)(3)*«.

F Cord-connected luminaires shall be located directly below the outlet box or busway »*410.62(C)(1)*«.



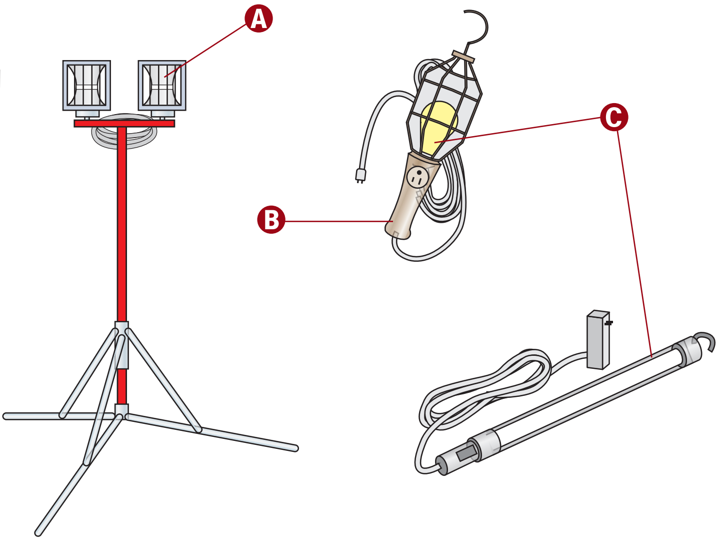
Portable Lamps

A Portable lamps must be wired with flexible cord, recognized by 400.4, and a polarized or grounding-type attachment plug »*410.82*«.

B Where used with Edison-base lampholders, the grounded conductor shall be identified and attached to the screw shell as well as the attachment plug's identified blade »*410.82*«.

C In addition to the provisions of 410.82, other requirements for temporary portable lamps must be met as well.

1. All lamps for general illumination shall be protected from accidental contact or breakage by suitable luminaire or lampholder with a guard »*590.4(F)*«.
2. Metal guarded sockets shall not be used unless the metal guard is connected to the circuit equipment grounding conductor »*590.4(F)*«.



Required Handhole in a Metal Pole

A This metal pole is more than 8 ft (2.5 m) tall abovegrade.

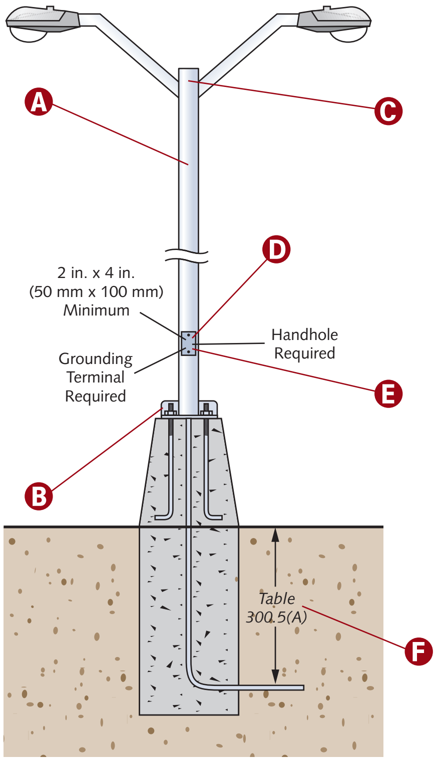
B Metal raceways or other equipment grounding conductors shall be bonded to the pole by means of an equipment grounding conductor recognized by 250.118 and sized in accordance with 250.122 »*410.30(B)(5)*«.

C Support conductors in vertical metal poles used as raceway, as provided in 300.19 »*410.30(B)(6)*«.

D A pole shall have a handhole not less than 2 in. × 4 in. (50 mm × 100 mm) with a cover suitable for use in wet locations to provide access to the supply terminations within the pole or pole base »*410.30(B)(1)*«.

E A metal pole with a handhole must have an equipment grounding terminal accessible from the handhole »*410.30(B)(3)(a)*«.

F Direct-buried cable, conduit, or other raceways must meet Table 300.5(A) minimum cover requirements »*300.5(A)*«.



Note

Where ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or (C), wire-type equipment grounding conductors, where installed, shall be increased in size proportionately according to the increase in circular mil area of the ungrounded conductors »***250.122(B)***«.

Hinged Metal Poles, 20 ft (6.0 m) or Less, Supporting Luminaires

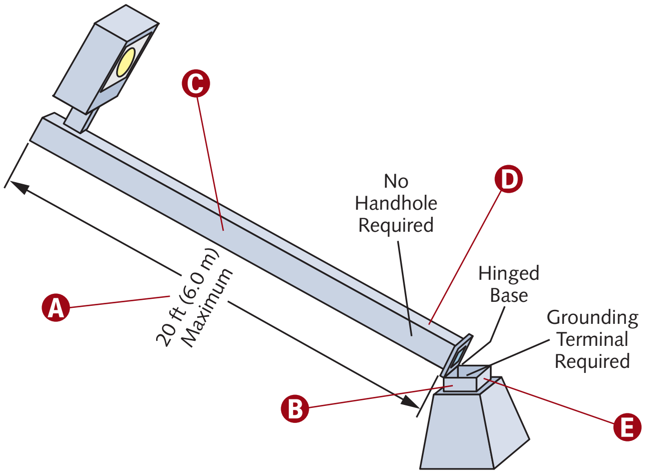
A A hinged-base pole longer than 20 ft (6.0 m) supporting a luminaire(s) requires a handhole »*410.30(B)(1)*«.

B A metal pole shall have an accessible grounding terminal within the base »*410.30(B)(3)(b)*«.

C A metal pole 20 ft (6.0 m) or less in height above grade that has a hinged base does not require a handhole »*410.30(B)(1) Exception No. 2*«.

D If equipped with a hinged base, the pole and base must be bonded together »*410.30(B)(4)*«.

E Metal raceways or other equipment grounding conductors shall be bonded to the pole by means of an equipment grounding conductor recognized by 250.118 and sized in accordance with 250.122 »*410.30(B)(5)*«.



Metal Poles, 8 ft (2.5 m) or Less, Supporting Luminaires

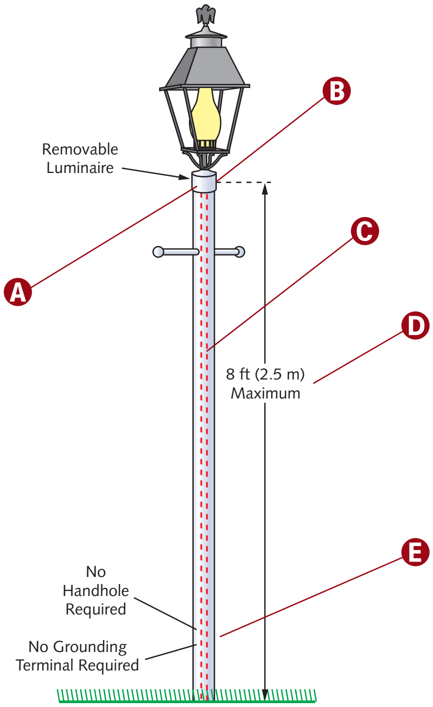
A No handhole is required in a pole no more than 8 ft (2.5 m) in height (abovegrade) where the supply wiring method continues without splice or pull point and where the pole interior and splices are accessible by removing the luminaire »*410.30(B)(1) Exception No. 1*«.

B Splices must remain accessible.

C The wiring method must continue without splice to the luminaire termination point.

D A pole longer than 8 ft (2.5 m) supporting a luminaire(s) requires a handhole »*410.30(B)(1)*«.

E No grounding terminal is required in a pole 8 ft (2.5 m) or less in height abovegrade where the supply wiring method continues without splice or pull point and where the pole interior and splices are accessible by luminaire removal »*410.30(B)(3) Exception*«.



Note

Receptacles of 15 and 20 amperes, 125 and 250 volts installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed and shall be identified as "extra duty." All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles shall be listed and so identified as the weather-resistant type **»406.9(B)(1)«**.

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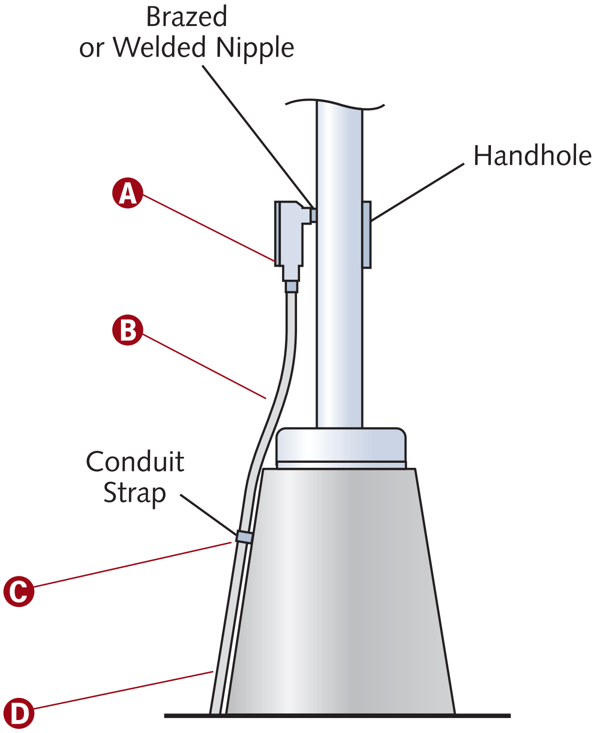
Supply Conductors Not Installed within the Pole

A Where cable or raceway risers are not installed within the pole, a threaded fitting (or nipple) shall be brazed (or welded) to the pole opposite the handhole for the supply connection »*410.30(B)(2)*«.

B Installed raceways subject to physical damage may require additional protection.

C Raceways, fittings, boxes, etc. must be securely fastened in place »*300.11(A)*«. Follow specific raceway support provisions for the type of raceway used.

D See Unit 5 for raceway provisions.



Summary

- Receptacle placement provisions for one-family and multi-family dwellings do not apply to commercial occupancies.
- Although a bathroom receptacle is not required in a commercial occupancy, it must be GFCI protected if installed.
- Each commercial building/occupancy accessible to pedestrians must be provided with at least one 20-ampere outlet in an accessible location at each entrance to every tenant space for sign or outline lighting systems use.
- One similarity in calculating branch-circuit conductors for continuous loads and motor loads is that each is multiplied by 125%.
- Article 440 contains air-conditioning and refrigeration equipment requirements.
- Commercial receptacles are computed at not less than 180 volt-amperes per strap.
- No more than ten receptacles are permitted on a 15-ampere branch circuit and thirteen on a 20-ampere branch circuit.
- At least two receptacle outlets must be readily accessible in guest rooms of hotels, motels, and similar occupancies.
- Table 220.42(A) gives the volt-ampere (per square foot) lighting load for non-dwelling occupancies.
- Calculate feeder or service track lighting at 150 volt-amperes for every 2 ft (600 mm) of lighting track or fraction thereof.
- Calculate feeder or service show-window lighting at not less than 200 volt-amperes per linear foot (300 mm) of show window.
- Certain luminaires, such as end-to-end connected fluorescent lights, have a limited use as raceways.

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- A handhole is required in a metal pole taller than 8 ft (2.5 m) abovegrade, unless the pole is no more than 20 ft (6.0 m) with a hinged base.
- At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed within an accessible location within 25 ft (7.5 m) of the indoor electrical service equipment.
- Receptacles of 15 and 20 amperes, 125 and 250 volts installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed and shall be identified as "extra-duty."
- All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles shall be listed and so identified as the weather-resistant type.

Unit 12 Competency Test

***NEC*® Reference** **Answer**

____________ ____________ 1. In calculating the load of lighting units that employ an autotransformer, the load shall be based on ____________.

____________ ____________ 2. ____________ luminaires used in a show window can be externally wired.

____________ ____________ 3. Luminaires shall be wired with conductors having insulation suitable for the __________ to which the conductors will be subjected.

____________ ____________ 4. Systems of illumination utilizing fluorescent lamps, high-intensity discharge (HID) lamps, or neon tubing are defined as ____________.

____________ ____________ 5. The term ____________ is defined as a complete lighting unit consisting of a light source such as a lamp or lamps, together with the parts designed to position the light source and connect it to the power supply.

____________ ____________ 6. The total rating of utilization equipment fastened in place, other than luminaires, shall not exceed ____________% of the branch-circuit ampere rating where lighting units, cord- and plug-connected utilization equipment not fastened in place, or both, are also supplied.

____________ ____________ 7. A metal pole supporting a luminaire must have a handhole not less than ____________ in. with a cover suitable for use in wet locations to provide access to the supply terminations within the pole or pole base.

____________ ____________ 8. Branch circuits that supply neon tubing installations shall not be rated in excess of ____________ amperes.

____________ ____________ 9. In accordance with the National Electrical Code, what is the minimum number of receptacles required in a bathroom located in an office occupancy? This bathroom will have two sinks. There will be a mirror on the wall behind the sinks and the owner does not want the mirror cut.

____________ ____________ 10. Lampholders of the screw shell type shall be installed for use as lampholders only. Where supplied by a circuit having a ____________ conductor, the ____________ conductor shall be connected to the screw shell.

____________ ____________ 11. When calculating track lighting loads for a commercial service, an additional load of ____________ volt-amperes shall be included for every ____________ ft of lighting track or fraction thereof.

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NEC® Reference **Answer**

____________ ____________ 12. The terminal of an electric-discharge lamp shall be considered as energized where any lamp terminal is connected to a circuit of over ____________.

____________ ____________ 13. ____________ luminaires surface mounted over concealed outlet, or pull or junction boxes and designed not to be supported solely by the outlet box shall be provided with suitable openings in back of the luminaire to provide access to the wiring in the boxes.

____________ ____________ 14. When calculating show-window lighting loads for a commercial service, a load of not less than ____________ shall be included for each linear foot of show window, measured horizontally along its base.

____________ ____________ 15. Twenty-four ft (six 4-ft sections) of track lighting must be installed in a continuous row in a retail store. What is the minimum number of supports required?

____________ ____________ 16. No handhole shall be required in a pole supporting a luminaire that is ____________ ft or less in height abovegrade where the supply wiring method continues without splice or pull point, and where the interior of the pole and any splices are accessible by removing the luminaire.

____________ ____________ 17. A hermetic refrigerant motor compressor's branch-circuit short-circuit and ground-fault protective device shall be capable of carrying ____________ of the motor's starting current.

a) 100% b) 125% c) 150% d) 175%

____________ ____________ 18. Heavy-duty lighting track is lighting track identified for use exceeding ____________.

____________ ____________ 19. At least ____________ receptacle outlet(s) shall be readily accessible in hotel and motel guest rooms.

____________ ____________ 20. Flexible cords shall be secured to the undersides of showcases so that a separation between cases not in excess of ____________ in. nor more than ____________ in. between the first case and the supply receptacle will be ensured.

____________ ____________ 21. Branch circuits that supply signs and outline lighting systems, other than neon, shall be rated not over ____________.

____________ ____________ 22. No handhole shall be required in a metal pole supporting a luminaire that is ____________ ft or less in height abovegrade that is provided with a hinged base.

____________ ____________ 23. A single piece of equipment consisting of a multiple receptacle comprising four or more receptacles shall be computed at not less than ____________ per receptacle.

____________ ____________ 24. Luminaires shall not be used as a raceway for circuit conductors unless they are ____________ and marked for use as a raceway.

____________ ____________ 25. At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed within 18 in. of the top of each show window. No point along the top of the window shall be farther than ____________ from a receptacle outlet.

____________ ____________ 26. On hermetic refrigerant motor compressors, the value of branch-circuit selection current will always be ____________ the marked rated-load current.

I. less than
II. equal to
III. greater than

a) I only b) I or II c) II or III d) III only

____________ ____________ 27. Electric-discharge luminaires provided with mogul-base, screw shell lampholders shall be permitted to be connected to branch circuits of ____________ amperes or less by cords complying with 240.5.

***NEC*® Reference** **Answer**

____________ ____________ 28. The load for the required sign branch circuit for a commercial occupancy shall be calculated at a minimum of ____________.

____________ ____________ 29. What is the minimum calculated branch-circuit lighting load (in volt-amperes) for a retail store with a floor area of 2,105 ft^2? The lighting in this store will be energized for more than 3 hours every day.

____________ ____________ 30. Lighting track shall be securely mounted so that each fastening will be suitable for supporting the maximum weight of luminaires that can be installed. Unless identified for supports at greater intervals, a single section ____________ ft or shorter in length shall have ____________ supports.

____________ ____________ 31. Switches, flashers, and similar devices controlling transformers and electronic power supplies for electric signs shall be rated for controlling inductive loads or have a current rating not less than ____________ of the current rating of the transformer or the electronic power supply.

a) 80% b) 100% c) 125% d) 200%

____________ ____________ 32. Conductors of ac and dc circuits rated 1000 volts ac, 1500 volts dc, nominal or less shall be permitted to occupy the same enclosure if:

a) all conductors within the enclosure have an insulation rating equal to at least 1000 volts.

b) all conductors operating at different voltage levels within the enclosure are separated by a permanent barrier.

c) all conductors have an insulation rating equal to at least the maximum circuit voltage applied to any conductor within the enclosure.

d) each conductor has an insulation rating equal to at least the maximum circuit voltage applied to each individual conductor within the enclosure.

____________ ____________ 33. Feeder and branch-circuit conductors within ____________ in. of a ballast, LED driver, power supply, or transformer shall have an insulation temperature rating not lower than 90°C (194°F), unless supplying a luminaire marked as suitable for a different insulation temperature.

____________ ____________ 34. The screw shell of all lampholders supplied by a grounded circuit shall be connected to the ____________ conductor.

____________ ____________ 35. Where connected to a branch circuit having a rating in excess of ____________, lampholders shall be of the heavy-duty type.

____________ ____________ 36. A recessed luminaire that is not identified for contact with insulation shall have all recessed parts spaced at least ____________ in. from combustible materials.

____________ ____________ 37. At least one 125-volt, single-phase, 15- or 20-ampere-rated receptacle outlet shall be installed in an accessible location within ____________ ft of the indoor electrical service equipment in a commercial building.

____________ ____________ 38. Receptacles of 15 and 20 amperes, 125 and 250 volts installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be ____________ and shall be identified as ____________.

____________ ____________ 39. What is the maximum number of duplex receptacles rated 15-amperes that can be installed on a 20-ampere circuit?

Unit

13

Section Four: Commercial Locations

Nondwelling Load Calculations

Objectives

After studying this unit, the student should:

- summarize elements required to perform a nondwelling load calculation.
- recall that receptacle outlets are counted, unlike in dwelling-unit load calculations.
- clarify how to apply Table 220.47 demand factors to receptacle loads in excess of 10 kVA.
- calculate the receptacle load for office buildings where the actual number of receptacle outlets is unknown.
- identify the volt-ampere unit loads used to calculate general lighting loads in nondwelling occupancies.
- explain when and how to apply Table 220.45 demand factors.
- recall that track lighting is calculated in addition to the general lighting load.
- clarify when to include a sign or outline lighting outlet in a load calculation.
- calculate show-window lighting loads.
- determine whether a load is continuous or noncontinuous and whether or not to add the additional 25% volt-ampere rating to the load calculation.
- recognize that the additional 25% volt-ampere rating for a continuous load is included when using the unit loads in Table 220.42(A) for calculating the minimum lighting load for a specified occupancy.
- recall that the load calculation rating represents only a minimum rating.

Introduction

Unit 13 contains a nondwelling load calculation form, along with a detailed explanation of each line. Dwelling calculations are covered in Unit 8 (one family) and Unit 11 (multifamily) of this text. Unlike dwelling unit load calculations, receptacle outlets are counted. Receptacle outlets (if known) and fixed multioutlet assemblies (if any) are entered into the calculation, and if the load is great enough, a demand factor is applied. As with dwelling-unit load calculations, general lighting is calculated using outside dimensions. Other items, such as a sign outlet (where required) and show window(s) (if present) are part of the nondwelling load calculation. The calculation for continuous loads (line 10) is very important. All continuous load ratings must be increased by 25%. When using the unit loads in Table 220.42(A) for calculating the minimum lighting load for a specified occupancy, it will not be necessary to increase the load by 25% because the additional 25% is already included. While kitchen equipment (line 11) is not included in every type of calculation, realize that kitchen equipment is not limited to restaurants. For instance, kitchen equipment could be a portion of a load calculation for a school. Line 14 (all other loads) is a catchall for any load not included otherwise in the calculation.

The load calculation form has little room for listing individual items, such as motors, equipment, etc. Depending on the size of the occupancy, the calculation could contain hundreds, if not thousands, of individual items. Space is also limited for certain calculations. When the need arises, simply attach additional sheets of paper containing extra items or calculations. Some procedures will not apply to certain load calculations. It is not recommended to leave a line blank or completely empty. Some predetermined marking should fill the space, such as a dashed line or the letters NA. One of the procedures (line 4) is applicable only in office buildings where the actual number of receptacle outlets is unknown.

The load calculation form results (overcurrent protection and conductors) represent only a *minimum* requirement. No consideration is given for the addition of future electrical loads. The size service or feeder is not restricted to the form's calculated size. For example, an electrician might install a 200-ampere service in an occupancy where the load calculation only required a 125-ampere rating.

Because certain cities, states, etc. require that some (if not all) electrical installations be designed by a licensed electrical engineer, caution is advised. Check with local authorities to determine these, as well as other, requirements.

Nondwelling Load Calculations

Line 1—Receptacle Load

A load of 15,300 volt-amperes would be placed in line 1 for a commercial occupancy having seventy-five duplex and ten single receptacles (75 + 10 = 85 × 180 = 15,300).

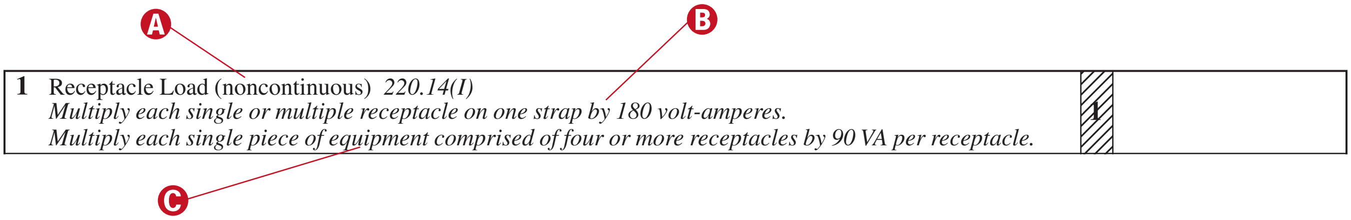
Ⓐ General-purpose receptacles are not continuous loads.

Ⓑ Receptacle outlets are calculated at a minimum of 180 volt-amperes for each single (or multiple) receptacle on one yoke (or strap) »*220.14(I)*« (see Unit 12).

Ⓒ A single piece of equipment (consisting of four or more receptacles) shall be calculated at no less than 90 volt-amperes per receptacle »*220.14(I)*« (see Unit 12).

Note

Because receptacles located in hotel/motel guest rooms and suites are included in the general lighting load calculation, no additional load calculation is required.



1 Receptacle Load (noncontinuous) *220.14(I)*
Multiply each single or multiple receptacle on one strap by 180 volt-amperes.
Multiply each single piece of equipment comprised of four or more receptacles by 90 VA per receptacle.

Line 2—Fixed Multioutlet Assembly Load

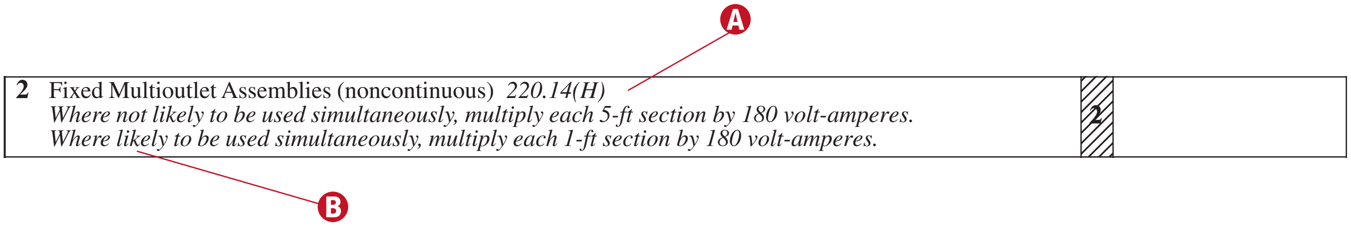
A commercial occupancy has 75 linear ft of fixed multioutlet assembly, with 15 ft of the assembly subject to simultaneous use. A load of 4860 volt-amperes is placed in line 2 because 75 − 15 = 60 ft (nonsimultaneous); 60 ÷ 5 = 12 × 180 = 2160 volt-amperes for nonsimultaneous use multioutlet assembly; 15 × 180 = 2700 volt-amperes for simultaneous use multioutlet assembly; and 2160 + 2700 = 4860 volt-amperes total for multioutlet assembly.

Ⓐ Where simultaneous use of appliances is unlikely, each 5-ft (1.5 m) or fraction thereof (of separate and continuous lengths) are considered one outlet of no less than 180 volt-amperes »*220.14(H)(1)*«. The number of receptacles within the 5-ft (1.5-m) measurement is irrelevant.

Ⓑ Where simultaneous use of appliances is likely, each 1 ft (300 mm) or fraction thereof shall be considered one outlet of no less than 180 volt-amperes »*220.14(H)(2)*«.

Note

Because fixed multioutlet assemblies in hotel/motel guest rooms and suites are included in the general lighting load calculation, no additional load calculation is needed.



2 Fixed Multioutlet Assemblies (noncontinuous) *220.14(H)*
Where not likely to be used simultaneously, multiply each 5-ft section by 180 volt-amperes.
Where likely to be used simultaneously, multiply each 1-ft section by 180 volt-amperes.

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Nondwelling Feeder/Service Load Calculation

1 Receptacle Load (noncontinuous) *220.14(I)* *Multiply each single or multiple receptacle on one strap by 180 volt-amperes.* *Multiply each single piece of equipment comprised of four or more receptacles by 90 VA per receptacle.*		1	
2 Fixed Multioutlet Assemblies (noncontinuous) *220.14(H)* *Where not likely to be used simultaneously, multiply each 5-ft section by 180 volt-amperes.* *Where likely to be used simultaneously, multiply each 1-ft section by 180 volt-amperes.*		2	
3 Receptacle Load Demand Factor (for nondwelling receptacles) *220.47* *If the receptacle load is more than 10,000 volt-amperes, apply the demand factor from Table 220.47.* *Add lines 1 and 2. Multiply the first 10 kVA or less by 100%. Then multiply the remainder by 50%.*		3	
4 Receptacle Load (office buildings only) *220.14(J)* *(1) Calculate the demand in line 3; (2) multiply 1 volt-ampere per square foot and add to line 4; and (3) compare lines 3 and 4 and omit the smaller.*	1 × ________ (sq-ft outside dimensions) =	4	
5 General Lighting Load *Table 220.42(A). Multiply the VA unit load (for the type of occupancy) by the square-foot outside dimensions. This table already includes the additional 25% for continuous loads.*	________ (VA unit load) × ________ (sq-ft outside dimensions) =	5	
6 Lighting Load Demand Factors *220.45. Apply Table 220.45 demand factors to certain portions of hotels, motels, apartment houses (without provisions for cooking), and storage warehouses. Do not include areas in hotels and motels where the entire lighting will be used at one time.*		6	
7 Track Lighting (in addition to general lighting) *220.46(B)* *Include 150 volt-amperes for every 2 ft, or fraction thereof, of lighting track. (Do not include track lighting in guest rooms or suites of hotels or motels.)*	________ (total linear ft) ÷ 2 ________ × 150 =	7	
8 Sign or Outline Lighting Outlet (where required) *220.14(F)* *Each commercial building (or occupancy) accessible to pedestrians must have at least one outlet per tenant space entrance. 600.5(A) Each outlet must be at least 1200 volt-amperes.*		8	
9 Show-Window Lighting *220.46(A)* *Include at least 200 volt-amperes for each linear foot, measured horizontally along the show window's base.*	________ (total linear ft of show window) × 200 =	9	
10 Continuous Loads *215.2(A)(1), 215.3,* and *230.42(A)(1)* *Multiply the continuous load volt-amperes (listed above) by 25%.* *(General-purpose receptacles are not considered continuous.)*	________ (total continuous load volt-amperes) × 25% =	10	
11 Kitchen Equipment *220.56* *Multiply three or more pieces of equipment by the Table 220.56 demand factor (%).* Use *Table 220.55* for household cooking equipment used in instructional programs. *Table 220.55,* Note 7		11	
12 Noncoincident Loads *220.60. The smaller of two (or more) noncoincident loads can be omitted, as long as they will never be energized simultaneously (such as certain portions of heating and A/C systems). Calculate fixed electric space-heating loads at 100% of the total connected load. 220.51*		12	
13 Motor Loads *220.11(A), 220.50, 430.24, 430.25, 430.26,* and Part IV of *Article 440* *Multiply the largest motor (one motor only) by 25% and add it to the load.* *If 25% of the largest motor is in line 12, leave line 13 blank.*		13	
14 All Other Loads. *Add all other noncontinuous loads into the calculation at 100%.* *Multiply all other continuous loads (operating for 3 hours or more) by 125%.*		14	
15 Total Volt-Ampere Demand Load: *Add lines 3 through 14 to find the minimum required volt-amperes.*		15	
16 Minimum Amperes *Divide the total volt-amperes by the voltage.* ________ (line 15) ÷ ________ (voltage) = **16** ________ (minimum amperes)	17 **Minimum Size Service or Feeder** ***240.6(A)***	17	
18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	18	
19 Size the Neutral Conductor. *220.61* *The neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, but not smaller than the maximum unbalanced load determined by Article 220. 250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1). A further demand factor is permitted for any neutral load over 200 amperes.*	**Minimum Size Neutral Conductor**	19	
20 Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	20	

Line 3—Receptacle Load Demand Factor

A commercial occupancy has a receptacle load of 15,300 volt-amperes and a fixed multioutlet assembly load of 4860. The total receptacle load is 20,160 volt-amperes. First, subtract 10,000 from the total receptacle load (20,160 − 10,000 = 10,160). Next, multiply the remainder by 50% (10,160 × 50% = 5080). Finally, add the result back to the original 10,000 volt-amperes (5080 + 10,000 = 15,080). The receptacle load, after demand, is then entered into line 3.

A Receptacle loads in nondwelling units are calculated at no more than 180 volt-amperes per outlet in accordance with 220.14(I), and fixed multioutlet assemblies are calculated per 220.14(H). Both can be added to the lighting load and made subject to the demand factors given in Table 220.45, or they can be made subject to Table 220.47 demand factors »*220.47*«.

B If the total receptacle load is no more than 10,000 volt-amperes, insert the number directly in line 3.

C If the total receptacle load is more than 10,000 volt-amperes, subtract 10,000 from the total, and multiply the remainder by 50%. Finally, add that number to the original 10,000 and place the total in line 3.

Note

General-purpose receptacles are not considered continuous loads.

A **B**

3	Receptacle Load Demand Factor (for nondwelling receptacles) *220.47* *If the receptacle load is more than 10,000 volt-amperes, apply the demand factor from Table 220.47. Add lines 1 and 2. Multiply the first 10 kVA or less by 100%. Then multiply the remainder by 50%.*	**3**	

C

Line 4—Receptacle Load (Office Buildings Only)

It is not known how many receptacles are in an 8500-ft² office building. A load of 8500 volt-amperes should be placed in line 4 (8500 × 1 = 8500). Since the actual number of receptacle outlets is unknown, line 3 would not contain a number.

A In office buildings, the receptacle load shall be calculated to be the larger of (1) the calculated load from 220.14(I) or (2) 1 volt-ampere per square foot »*220.14(J)*«.

B First, calculate the receptacle load in line 3. Next, multiply the square foot dimensions by 1 and insert in line 4. Finally, compare the two and omit the smaller.

C If the actual number of general-purpose receptacle outlets is unknown, multiply the square foot dimension by 1 and insert in line 4.

Caution

Line 4 applies only to office building occupancies.

A **B** **C**

4	Receptacle Load (office buildings only) *220.14(J)* *(1) Calculate the demand in line 3; (2) multiply 1 volt-ampere per square foot and add to line 4; and (3) compare lines 3 and 4 and omit the smaller.*	1 × ____________ = (sq-ft outside dimensions)	**4**	

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Line 5—General Lighting Load

An 8500-ft² office building has a general lighting load of 11,050 volt-amperes (8500 × 1.3 = 11,050). The receptacle load, whether known or unknown, is not used here.

A 30,000-ft² store has a general lighting load of 57,000 volt-amperes (30,000 × 1.9 = 57,000). Stores are considered retail occupancies.

A A unit load that meets or exceeds that specified in Table 220.42(A) for listed occupancies constitutes the minimum lighting load for each square foot of floor area »*220.5(C)* and *220.42(A)*«.

Note

Where the building is designed and constructed to comply with an energy code adopted by the local authority, the lighting load shall be permitted to be calculated at the values specified in the energy code where the following conditions are met:
(1) A power monitoring system is installed that will provide continuous information regarding the total general lighting load of the building.
(2) The power monitoring system will be set with alarm values to alert the building owner or manager if the lighting load exceeds the values set by the energy code.
(3) The demand factors specified in 220.45 are not applied to the general lighting load.
(4) The continuous load multiplier of 125% shall be applied ***»220.42(B)«***.

B Find the correct volt-ampere unit load located across from the occupancy type, and insert it into the calculation »*Table 220.42(A)*«.

C Each floor's area shall be calculated using the building's (or area's) outside dimensions »*220.5(C)*«.

Note

Specific areas such as halls, corridors, closets, stairways, and storage spaces are already included in the occupancies listed in Table 220.42(A). Armories and auditoriums are considered gymnasium-type occupancies.

Note

The 125% multiplier for a continuous load as specified in 210.20(A) is included when using the unit loads in Table 220.42(A) for calculating the minimum lighting load for a specified occupancy ***»Note to Table 220.42(A)«***. When the load calculation includes the use of volt-ampere unit loads from Table 220.12, do not increase this load by the additional 25%.

A **B** **C**

5 General Lighting Load *Table 220.42(A). Multiply the VA unit load (for the type of occupancy) by the square-foot outside dimensions. This table already includes the additional 25% for continuous loads.*	______ × ______ = (VA unit load) (sq-ft outside dimensions)	**5**	

Line 6—Lighting Load Demand Factors

Find the general lighting load (after applying the lighting load demand factors) for guest rooms in a hotel where the room dimensions total 100,000 ft². First, multiply 100,000 by the hotel volt-ampere unit load (1.7), found in Table 220.42(A) (100,000 × 1.7 = 170,000). Now, multiply the first 20,000 by 60% (20,000 × 60% = 12,000). Next multiply the next 80,000 by 50% (80,000 × 50% = 40,000). Now multiply the remainder by 35% (70,000 × 35% = 24,500). Finally, add the three figures (12,000 + 40,000 + 24,5000 = 76,500). The general lighting load after applying the lighting load demand factors in Table 220.45 for guest rooms in a hotel where the room dimensions total 100,000 ft² is 76,500 volt-amperes.

A Demand factors apply to certain areas in hotels, motels, apartment houses (without cooking provisions), and warehouses.

B Do not include areas in hotels and motels where all lighting is subject to simultaneous use. Primarily, such lighting is considered a continuous load. Continuous loads must not be derated by Table 220.45.

Note

Do not use Table 220.45 to determine the total number of branch circuits ***»220.45«***.

A

6 Lighting Load Demand Factors *220.45. Apply Table 220.45 demand factors to certain portions of hotels, motels, apartment houses (without provisions for cooking), and storage warehouses. Do not include areas in hotels and motels where the entire lighting will be used at one time.*	**6**	

B

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Line 7—Track Lighting

A store having 80 ft of lighting track has an additional lighting load of 6000 volt-amperes. First divide the total length of lighting track by two (80 ÷ 2 = 40). Then multiply the result by 150 volt-amperes (40 × 150 = 6000).

Ⓐ Do not consider track lighting in dwelling unit (or hotel/motel guest room or suite) service or feeder load calculations »*220.46(B)*«.

Ⓑ Track lighting is calculated in addition to the occupancy general lighting load, found in Table 220.42(A).

Ⓒ Multiply each 2-ft section, or fraction thereof, by 150 volt-amperes »*220.46(B)*«.

Ⓐ Ⓑ

7	Track Lighting (in addition to general lighting) *220.46(B)* *Include 150 volt-amperes for every 2 ft, or fraction thereof, of lighting track. (Do not include track lighting in guest rooms or suites of hotels or motels.)*	________ ÷ 2 ________ × 150 = (total linear ft)	**7**

Ⓒ

Line 8—Sign or Outline Lighting

Ⓐ Each commercial building (or occupancy) accessible to pedestrians shall be provided with at least one outlet in a location accessible to each tenant space entrance for sign or outline lighting system use »*600.5(A)*«.

Ⓑ Each sign and outline lighting outlet is computed at a minimum of 1200 volt-amperes »*220.14(F)*«.

Note

A sign or outline lighting outlet shall not be required at entrances for deliveries, service corridors, or service hallways that are intended to be used only by service personnel or employees »***600.5(A)***«.

Caution

If the rating is more than 1200 volt-amperes, use the actual rating of the sign or outline lighting.

Ⓐ

8	Sign or Outline Lighting Outlet (where required) *220.14(F)* *Each commercial building (or occupancy) accessible to pedestrians must have at least one outlet per tenant space entrance. 600.5(A) Each outlet must be at least 1200 volt-amperes.*	**8**

Ⓑ

Line 9—Show-Window Lighting

A store having 75 linear ft of show-window space has a feeder /service load of 15,000 volt-amperes (75 × 200 = 15,000).

Ⓐ If an occupancy has show window(s), include at least 200 volt-amperes for each linear foot, measured horizontally along the show window's base »*220.46(A)*«.

Note

Calculate show-window branch circuits in accordance with 220.14(G).

Ⓐ

9	Show-Window Lighting *220.46(A)* *Include at least 200 volt-amperes for each linear foot, measured horizontally along the show window's base.*	____________ × 200 = (total linear ft of show window)	**9**

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Line 10—Continuous Loads

Feeder conductors shall have an ampacity not less than required to supply the load as calculated in Parts III, IV, and V of *Article 220*. Conductors shall be sized to carry not less than the larger of 215.2(A)(1) or (A)(2).
(1) Where a feeder supplies continuous loads or any combination of continuous and noncontinuous loads, the minimum feeder conductor size shall have an allowable ampacity not less than the noncontinuous load plus 125% of the continuous load. (2) The minimum feeder conductor size shall have an allowable ampacity not less than the maximum load to be served after the application of any adjustment or correction factors »*215.2(A)*«.

Ⓐ A load where the maximum current is expected to continue for three hours or more is a continuous load »*Article 100*«.

Ⓑ Feeder conductors and overcurrent protection shall be sized at 100% of noncontinuous loads *plus* 125% of continuous loads »*215.2(A)(1)* and *215.3*«. In other words, an additional 25% of the volt-ampere rating must be added to the continuous loads. This form simplifies that computation. Add all of the continuous loads (listed above line 10) and multiply by 25%. This rule also applies to service-entrance conductors »*230.42(A)(1)*«.

Ⓒ General-purpose receptacles and multioutlet assemblies are not included in this calculation.

Ⓓ Total all of the *continuous* loads listed in lines 5 through 9. These lines are not automatically considered continuous. Only if the load is expected to continue for three hours or more is it a continuous load. Examples may include, but are not limited to, track lighting, show-window lighting, signs, and outline lighting.

Ⓔ Lighting loads calculated from Table *220.42(A)* already include the additional 25% for continuous loads so do not include those volt-amperes in this line of the calculation.

Note

There are three exceptions under 215.2(A)(1) for having to multiply the continuous load by 125%:
If the assembly, including the overcurrent devices protecting the feeder(s), is listed for operation at 100% of its rating, the allowable ampacity of the feeder conductors shall be permitted to be not less than the sum of the continuous load plus the noncontinuous load [Exception No. 1].
Where a portion of a feeder is connected at both its supply and load ends to separately installed pressure connections as covered in 110.14(C)(2), it shall be permitted to have an allowable ampacity not less than the sum of the continuous load plus the noncontinuous load. No portion of a feeder installed under the provisions of this exception shall extend into an enclosure containing either the feeder supply or the feeder load terminations, as covered in 110.14(C)(1) [Exception No. 2].
Grounded conductors that are not connected to an overcurrent device shall be permitted to be sized at 100% of the continuous and noncontinuous load [Exception No. 3].

Ⓐ Ⓑ Ⓔ

10 Continuous Loads *215.2(A)(1), 215.3,* and *230.42(A)(1)*
Multiply the continuous load volt-amperes (listed above) by 25%. ________________ × 25% = **10**
(General-purpose receptacles are not considered continuous.) (total continuous load volt-amperes)

Ⓒ Ⓓ

Line 11—Kitchen Equipment

Ⓐ Calculate the load for commercial electric cooking equipment, dishwasher booster heaters, water heaters, and other kitchen equipment in accordance with Table 220.56. Apply the demand factors to all equipment that (1) has thermostatic control or (2) is intermittently used as kitchen equipment »*220.56*«.

Ⓑ Table 220.56 is relatively simple. No derating is allowed for only one or two pieces of equipment. The demand factor for three pieces of equipment is 90%; for four pieces, 80%; and for five pieces, 70%. The demand factor for more than five pieces of equipment is 65%.

Ⓒ For household cooking appliances rated over 1¾ kW and used in instructional programs, refer to Table 220.55 »*Table 220.55, Note 7*«. For example, in a school home-economics classroom, a feeder supplying 20 12-kW household electric ranges requires a minimum rating of only 35 kW »*Table 220.55, Column C*«.

Note

Table 220.56 does not apply to space-heating, ventilating, or air-conditioning equipment. The demand factors in Table 220.56 can be applied to other kitchen equipment that is fastened in place and rated ¼ hp or greater, or 500 watts or greater »*220.56*«.

Caution

The feeder or service calculated load can never be smaller than the combined rating of the two largest kitchen equipment loads »*220.56*«.

Ⓐ Ⓑ

11 Kitchen Equipment *220.56* **11**
Multiply three or more pieces of equipment by the Table 220.56 demand factor (%).
Use *Table 220.55* for household cooking equipment used in instructional programs. *Table 220.55,* Note 7

Ⓒ

Line 12—Noncoincident Loads

A If it is unlikely that multiple noncoincident loads will be used simultaneously, use only the largest load(s) that will be used at one time in calculating the total feeder/service load »*220.60*«.

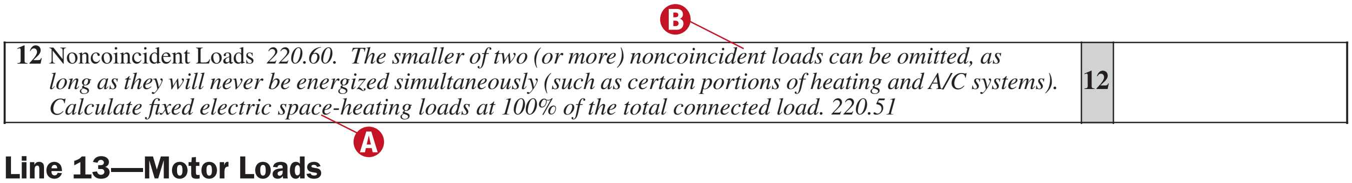
B While fixed electric space-heating loads are calculated at 100% of the total connected load, in no case shall a feeder or service load current rating be less than the rating of the largest branch circuit supplied »*220.51*«.

Note

If reduced loading of the conductors results from units operating on duty cycle or intermittently, or from all units not operating at one time, the AHJ shall be permitted to grant permission for feeder and service conductors to have an ampacity less than 100%, if the conductors have an ampacity for the load so determined »***220.51 Exception***«.

Note

If a motor or air-conditioning load is part of the noncoincident load and is not the largest of the noncoincident loads, 125% of either the motor or air-conditioning load, whichever is larger, load shall be used in the calculation »***220.60***«.


B

12 Noncoincident Loads *220.60. The smaller of two (or more) noncoincident loads can be omitted, as long as they will never be energized simultaneously (such as certain portions of heating and A/C systems). Calculate fixed electric space-heating loads at 100% of the total connected load. 220.51* **12**

A

Line 13—Motor Loads

Where one or more of the motors of the group are used for short-time, intermittent, periodic, or varying duty, the ampere rating of such motors used in the summation shall be determined in accordance with 430.22(E). For the highest-rated motor, the greater of either the ampere rating from 430.22(E) or the largest continuous-duty motor full-load current multiplied by 1.25 shall be used in the summation »*430.24 Exception No. 1*«.

Where interlocked circuitry prevents simultaneous operation of selected motors or other loads, the conductor ampacity shall be permitted to be based on the summation of the currents of the motors and other loads being operated simultaneously resulting in the highest total current »*430.24 Exception No. 3*«.

A The ampacity of the conductors supplying multimotor and combination-load equipment shall not be less than the minimum circuit ampacity marked on the equipment per 430.7(D). If the individual equipment nameplates are visible (per 430.7[D][2]), but the equipment is not factory wired, use 430.24 to determine conductor ampacity »*430.25*«.

B Where conductor heating is reduced as a result of motors operating on duty cycle, intermittently, or from all motors not operating at one time, the AHJ may grant permission for feeder conductors to have an ampacity less than specified in 430.24, provided the conductors have sufficient ampacity for the number of motors supplied and the nature of their loads and duties »*430.26*«.

C Conductors supplying several motors or a motor(s) and other load(s) must have an ampacity not less than the sum of each of the following:

(1) 125% of the full-load current rating of the highest rated motor, as determined by 430.6(A)

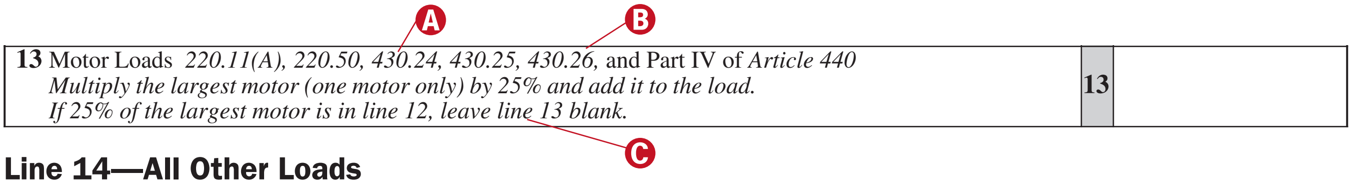
(2) Sum of the full-load current ratings of all the other motors in the group, as determined by 430.6(A)

(3) 100% of the noncontinuous nonmotor load

(4) 125% of the continuous nonmotor load »*430.24*«.

Note

If the largest motor is the air-conditioner compressor motor and it was not omitted, it is already in the calculation at 125%. When 25% of the largest motor is in line 12, leave line 13 blank or insert a zero.


A **B**

13 Motor Loads *220.11(A), 220.50, 430.24, 430.25, 430.26,* and Part IV of *Article 440 Multiply the largest motor (one motor only) by 25% and add it to the load. If 25% of the largest motor is in line 12, leave line 13 blank.* **13**

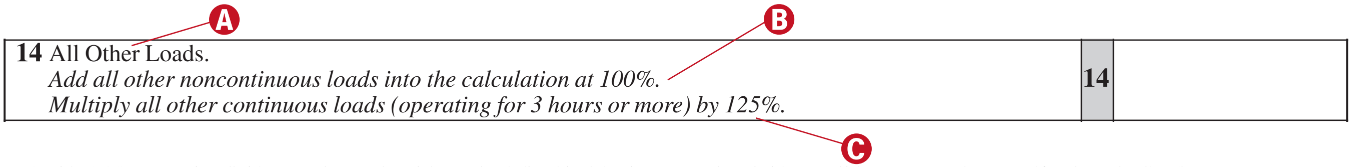
C

Line 14—All Other Loads

A This line is a catchall for loads not falling into one of the previous categories.

B Calculate all noncontinuous loads (not yet input) at 100% of their volt-ampere rating.

C Total all continuous loads (not yet calculated) and multiply by 125%. Add the result of the continuous loads to that for noncontinuous loads and put the total on line 14.


A **B**

14 All Other Loads. *Add all other noncontinuous loads into the calculation at 100%. Multiply all other continuous loads (operating for 3 hours or more) by 125%.* **14**

C

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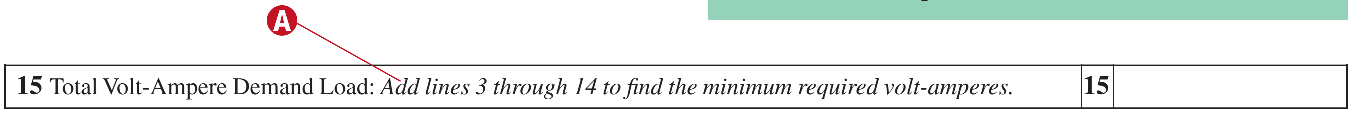
Line 15—Total Volt-Ampere Demand Load

A Add all volt-ampere loads listed in lines 3 through 14 and place the result in line 15.

Note

Not all lines will contain volt-ampere loads. Be sure to add only the lines containing loads. For example, if the actual number of receptacles in an office building is known, line 4 will not contain a figure.



15 Total Volt-Ampere Demand Load: *Add lines 3 through 14 to find the minimum required volt-amperes.* **15**

Lines 16 and 17—Minimum Size Service or Feeder

A Place the total volt-ampere amount found in line 15 here.

B Write down the source voltage that supplies the feeder/service.

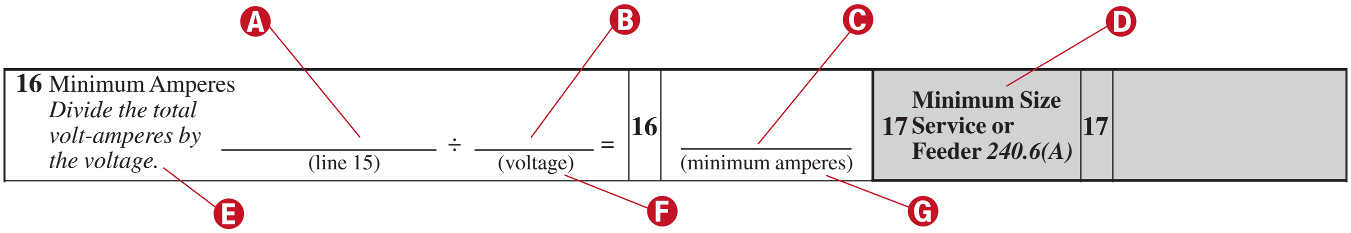
C Fractions of an ampere 0.5 and higher are rounded up, while fractions less than 0.5 are dropped »*220.5(B)*«.

D The service (or feeder) overcurrent protection must be higher than the number found in line 16. Refer to 240.6(A) for a list of fuse and circuit breaker standard ampere ratings.

E Divide the volt-amperes by the voltage to find the amperage.

F Three-phase voltage is found by multiplying the voltage (single-phase) by 1.732. For example, the source voltage for 208-volt, 3-phase is 360 (208 × 1.732).

G The result on line 16 is the minimum amperage rating required for the service or feeder being calculated.



16 Minimum Amperes
Divide the total volt-amperes by the voltage. ________ (line 15) ÷ ________ (voltage) = **16** ________ (minimum amperes)

17 Minimum Size Service or Feeder ***240.6(A)*** **17**

Line 18—Minimum Size Conductors

Conductors 1/0 AWG and larger can be connected in parallel (electrically joined at both ends to form a single conductor) »*310.10(G)(1)*«.

The number and type of paralleled conductor sets is a design consideration, not necessarily a *Code* issue. Exercise extreme care when designing a paralleled conductor installation without violating provisions such as 110.14(A), 110.14(C), 240.4(C), 250.66, 250.122(F), 300.20(A), 310.10(G), etc.

A Using Tables 310.16 through 310.21, choose a conductor size that equals (or exceeds) line 16's minimum ampacity rating. The conductor's ampacity rating does not have to equal or exceed the overcurrent device rating unless its rating exceeds 800 amperes »*240.4(B)*«.

B Ampacity adjustment (correction) factors for more than three current-carrying conductors are located in Table 310.15(C)(1).

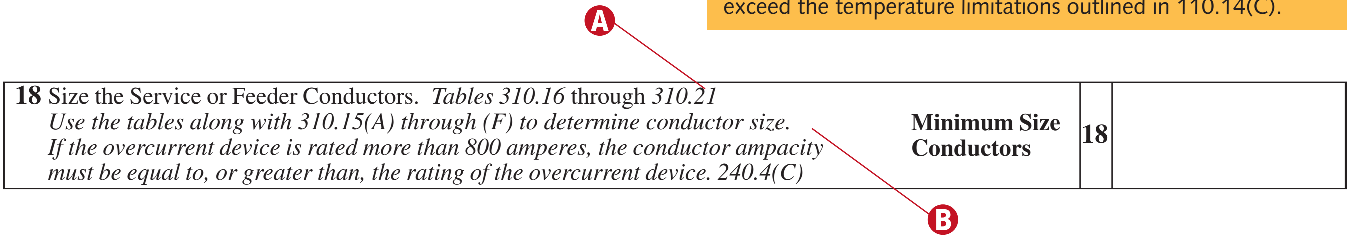
Note

The paralleled conductors in each phase, polarity, neutral, grounded circuit conductor, equipment grounding conductor, or equipment bonding jumper shall share the same characteristics »***310.10(G)(2)***«. For example, all paralleled, Phase A conductors must:

(1) be of the same length,
(2) consist of the same conductor material,
(3) be the same size in circular mil area,
(4) have the same insulation type, and
(5) be terminated in the same manner.

Warning

For overcurrent devices rated over 800 amperes, the ampacity of the conductors protected shall equal or exceed the rating of the overcurrent device per 240.6 »*240.4(C)*«. Do not exceed the temperature limitations outlined in 110.14(C).



18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21*
Use the tables along with 310.15(A) through (F) to determine conductor size.
If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)

Minimum Size Conductors **18**

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Line 19—Neutral Conductor

Include all lighting and receptacle loads having a 120-volt rating in the neutral calculation.

All appliances, equipment, motors, etc. utilizing a grounded conductor are included in the neutral calculation.

Ⓐ For the purpose of this load calculation, the terms **neutral** and **grounded** are synonymous.

Ⓑ The feeder (or service) neutral load is the maximum unbalance of the load determined by Article 220 »*220.61*«.

Ⓒ In addition to 220.61 demand factors, a 70% demand factor is permitted for that portion of the unbalanced load above 200 amperes for most common electrical systems »*220.61(B)(2)*«.

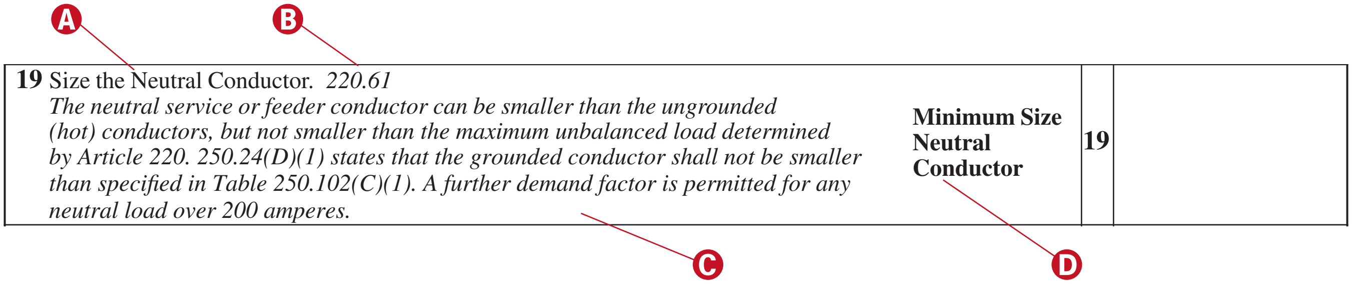
Ⓓ The neutral is sized by finding the maximum unbalanced load.

Note

The grounded conductor for services shall not be smaller than specified in Table 250.102(C)(1) »***250.24(D)(1)***«. The grounded conductor for feeders shall not be smaller than specified in Table 250.122 »***215.2(B)***«.

Caution

Reduction of neutral capacity is not permitted for that portion of the load consisting of nonlinear loads supplied from a 4-wire, wye-connected, 3-phase system nor the grounded conductor of a 3-wire circuit consisting of 2-phase wires and the neutral of a 4-wire, 3-phase, wye-connected system »*220.61(C)*«.



19 Size the Neutral Conductor. *220.61*
The neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, but not smaller than the maximum unbalanced load determined by Article 220. 250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1). A further demand factor is permitted for any neutral load over 200 amperes.

Minimum Size Neutral Conductor **19**

Line 20—Grounding Conductor

If the grounding electrode conductor or bonding jumper connected to a single or multiple rod, pipe, or plate electrode(s), or any combination thereof, as described in 250.52(A)(5) or (A)(7), does not extend on to other types of electrodes that require a larger size conductor, the grounding electrode conductor shall not be required to be larger than 6 AWG copper wire or 4 AWG aluminum »*250.66(A)*«.

If the grounding electrode conductor or bonding jumper connected to a single or multiple concrete-encased electrode(s), as described in 250.52(A)(3), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than 4 AWG copper wire »*250.66(B)*«.

If the grounding electrode conductor or bonding jumper connected to a ground ring, as described in 250.52(A)(4), does not extend on to other types of electrodes that require a larger size of conductor, the grounding electrode conductor shall not be required to be larger than the conductor used for the ground ring »*250.66(C)*«.

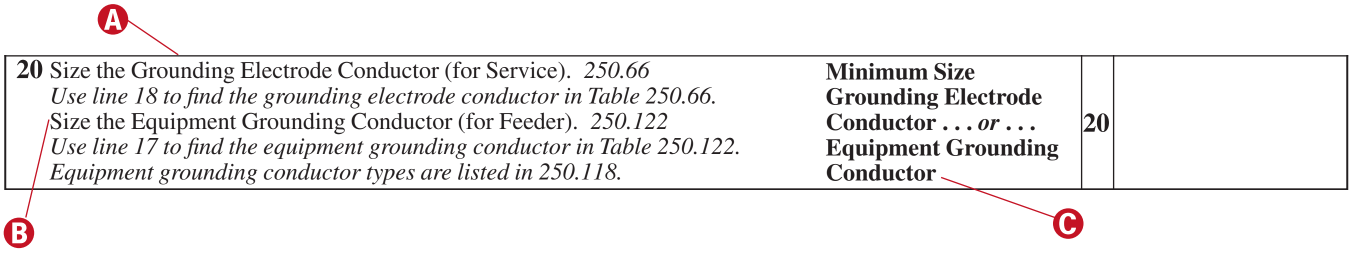
Ⓐ Grounding electrode conductor size is based on the largest ungrounded conductor or equivalent area for parallel conductors »*Table 250.66*«. (The minimum size service-entrance conductors were determined on line 18.)

Ⓑ Equipment bonding jumpers on the load side of an overcurrent device(s) shall be sized in accordance with 250.122 »*250.102(D)*«.

Ⓒ The equipment grounding conductor size is based on the rating (or setting) of the circuit's automatic overcurrent device ahead of equipment, conduit, etc. »*Table 250.122*«.

Caution

250.66(A) allows the sole connection to a ground rod, pipe, or plate to be 6 AWG copper, but many jurisdictions and power companies require larger grounding electrode conductors. Always verify local rules with the AHJ and local power company.



20 Size the Grounding Electrode Conductor (for Service). *250.66*
Use line 18 to find the grounding electrode conductor in Table 250.66.
Size the Equipment Grounding Conductor (for Feeder). *250.122*
Use line 17 to find the equipment grounding conductor in Table 250.122.
Equipment grounding conductor types are listed in 250.118.

Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor **20**

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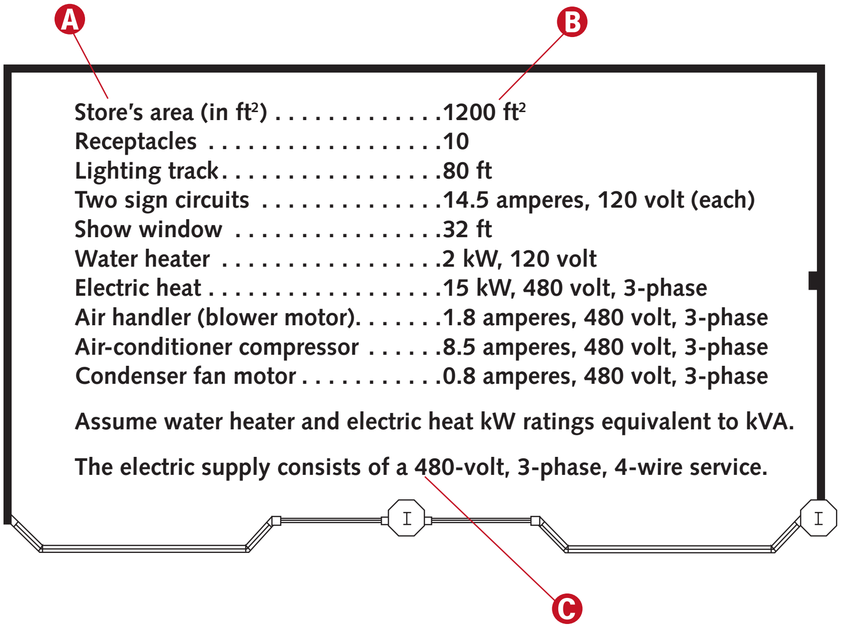
Sample Load Calculation—Store

Load Calculation Information

Ⓐ This is the load calculation data for a small retail store.

Ⓑ Calculate the floor area from the outside dimensions. In this example, the square-foot area is already provided.

Ⓒ A 3-phase transformer steps down the voltage from 480 to 208Y/120 volts.



Store's area (in ft²)	**1200 ft²**
Receptacles	**10**
Lighting track	**80 ft**
Two sign circuits	**14.5 amperes, 120 volt (each)**
Show window	**32 ft**
Water heater	**2 kW, 120 volt**
Electric heat	**15 kW, 480 volt, 3-phase**
Air handler (blower motor).	**1.8 amperes, 480 volt, 3-phase**
Air-conditioner compressor	**8.5 amperes, 480 volt, 3-phase**
Condenser fan motor	**0.8 amperes, 480 volt, 3-phase**

Assume water heater and electric heat kW ratings equivalent to kVA.

The electric supply consists of a 480-volt, 3-phase, 4-wire service.

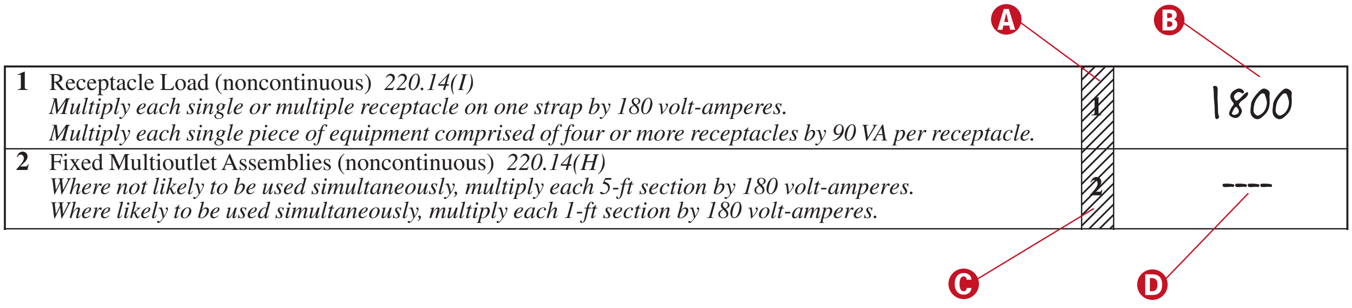
Lines 1 and 2

Ⓐ The different style of box on line 1 (unlike lines 3 through 14) indicates that the load will become part (if not all) of line 3. Line 1 is not included in line 15's total volt-ampere demand load.

Ⓑ Since there are ten receptacles, the calculated load is 1800 volt-amperes (10 × 180).

Ⓒ As with line 1, line 2 has a different style box from lines 3 through 14 because the load (if any) becomes part of line 3. Line 2 is not included in line 15's total volt-ampere demand load.

Ⓓ Because this store has no fixed multioutlet assembly, a dashed line occupies line 2.



1	Receptacle Load (noncontinuous) *220.14(I)* *Multiply each single or multiple receptacle on one strap by 180 volt-amperes.* *Multiply each single piece of equipment comprised of four or more receptacles by 90 VA per receptacle.*	1	1800
2	Fixed Multioutlet Assemblies (noncontinuous) *220.14(H)* *Where not likely to be used simultaneously, multiply each 5-ft section by 180 volt-amperes.* *Where likely to be used simultaneously, multiply each 1-ft section by 180 volt-amperes.*	2	----

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Lines 3 and 4

A Line 3 is the first of 12 lines whose values are combined to determine the total volt-ampere demand load.

B Because there is no multioutlet assembly and the receptacle load is less than 10 kVA, the 1800 volt-ampere load from line 1 is inserted in line 3.

C Line 4 is only used for office buildings. Multiply the square footage of the office building by 1 volt-ampere and compare to line 3. Use only the larger of lines 3 or 4.

D The dashed line indicates line 4 is intentionally blank, because it only applies to office buildings.

A B

3	Receptacle Load Demand Factor (for nondwelling receptacles) *220.47* *If the receptacle load is more than 10,000 volt-amperes, apply the demand factor from Table 220.47. Add lines 1 and 2. Multiply the first 10 kVA or less by 100%. Then multiply the remainder by 50%.*		**3**	1800
4	Receptacle Load (office buildings only) *220.14(J)* *(1) Calculate the demand in line 3; (2) multiply 1 volt-ampere per square foot and add to line 4; and (3) compare lines 3 and 4 and omit the smaller.*	1 × ---- (sq-ft outside dimensions) =	**4**	----

C D

Lines 5 and 6

A The volt-ampere unit load for a store is 1.9 »*Table 220.42(A)*«.

B Since the store's square-foot area is provided, no calculation is required.

C Store lighting by definition is a continuous load but in accordance with the note below Table 220.42(A), the 125% multiplier for continuous loads is already included in the volt-ampere unit load. Therefore, do not add the result of line 5 to line 10.

D Use line 6 only for certain portions of hotels, motels, storage warehouses, and apartment houses without provisions for cooking.

E The marking in line 6 indicates that it has intentionally been left blank.

A B C

5	General Lighting Load *Table 220.42(A). Multiply the VA unit load (for the type of occupancy) by the square-foot outside dimensions. This table already includes the additional 25% for continuous loads.*	1.9 (VA unit load) × 1200 (sq-ft outside dimensions) =	**5**	2280
6	Lighting Load Demand Factors *220.45. Apply Table 220.45 demand factors to certain portions of hotels, motels, apartment houses (without provisions for cooking), and storage warehouses. Do not include areas in hotels and motels where the entire lighting will be used at one time.*		**6**	----

D E

Lines 7 and 8

A Except for dwelling units or hotel/motel guest rooms, track lighting loads are additional to Table 220.42(A)'s general lighting loads »*220.46(B)*«.

B This store contains 80 ft of lighting track.

C Base the calculation on every 2 ft, or fraction thereof, of track.

D A store's track lighting load is continuous. Line 7's result becomes part of the continuous volt-ampere load calculation (line 10).

E At least one outlet having a minimum rating of 1200 volt-amperes is required.

F This store's actual sign load is 3420 volt-amperes (2 × 14.5 × 120). This store has two sign circuits.

G Since a store's sign load is continuous, the result of line 8 becomes part of the continuous volt-ampere load calculation (line 10).

A B C D

7	Track Lighting (in addition to general lighting) *220.46(B)* *Include 150 volt-amperes for every 2 ft, or fraction thereof, of lighting track. (Do not include track lighting in guest rooms or suites of hotels or motels.)*	80 (total linear ft) ÷ 2 40 × 150 =	**7**	6000
8	Sign or Outline Lighting Outlet (where required) *220.14(F)* *Each commercial building (or occupancy) accessible to pedestrians must have at least one outlet per tenant space entrance. 600.5(A) Each outlet must be at least 1200 volt-amperes.*		**8**	3480

E F G

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Line 9

Ⓐ Not all commercial occupancies have show windows.

Ⓑ The store in this example has 32 linear ft of show window.

Ⓒ Because show-window load is continuous, the result of line 9 becomes part of the continuous volt-ampere load calculation (line 10).

9 Ⓐ Show-Window Lighting *220.46(A)* *Include at least 200 volt-amperes for each linear foot, measured horizontally along the show window's base.*	Ⓑ 32 (total linear ft of show window) × 200 =	**9**	Ⓒ 6400

Lines 10 and 11

Ⓐ Lines 7, 8, and 9 represent the store's continuous loads.

Ⓑ 6000 + 3480 + 6400 = 15,880

Ⓒ An additional 25% volt-ampere load has been added because of the continuous loads.

Ⓓ The marking in line 11 indicates a lack of kitchen equipment.

10 Ⓐ Continuous Loads *215.2(A)(1), 215.3,* and *230.42(A)(1)* *Multiply the continuous load volt-amperes (listed above) by 25%.* *(General-purpose receptacles are not considered continuous.)*	Ⓑ 15,880 (total continuous load volt-amperes) × 25% =	**10**	Ⓒ 3970
11 Kitchen Equipment *220.56* *Multiply three or more pieces of equipment by the Table 220.56 demand factor (%).* Use *Table 220.55* for household cooking equipment used in instructional programs. *Table 220.55,* Note 7		**11**	---- Ⓓ

Lines 12 and 13

The air handler (blower motor) has a rating of 1496 volt-amperes (1.8 × 480 × 1.732 = 1496). Since the heat and the blower are energized simultaneously, add the air handler to the 15 kW of electric heat. The heating load for this store is 16,496 volt-amperes (15,000 + 1496 = 16,496).

The air-conditioner compressor motor has a rating of 8833 volt-amperes (8.5 × 480 × 1.732 × 125% = 8833).

Ⓐ Because the combined electric heat and air-handler load is larger than the combined compressor, condenser fan motor, and air handler, omit the compressor and condenser fan motor load.

The condenser fan motor has a rating of 665 volt-amperes (0.8 × 480 × 1.732 = 665). The blower motor has a rating of 1496 volt-amperes (1.8 × 480 × 1.732 = 1496). The air-conditioning load is 10,994 volt-amperes (8833 + 665 + 1496 = 10,994). Because this total is less than the heating load, omit the air-conditioner compressor and the condenser fan motor.

Ⓑ Find the largest motor. In this example, that would be the air-handler motor (1.8 × 480 × 1.732 = 1,496). Increase the largest motor by 25% (1,496 × 25% = 374).

12 Noncoincident Loads *220.60. The smaller of two (or more) noncoincident loads can be omitted, as long as they will never be energized simultaneously (such as certain portions of heating and A/C systems).* *Calculate fixed electric space-heating loads at 100% of the total connected load. 220.51*	**12**	Ⓐ 16,496
13 Motor Loads *220.11(A), 220.50, 430.24, 430.25, 430.26,* and Part IV of *Article 440* *Multiply the largest motor (one motor only) by 25% and add it to the load.* *If 25% of the largest motor is in line 12, leave line 13 blank.*	**13**	374 Ⓑ

Lines 14 and 15

Ⓐ The only load not previously calculated is the water heater. A water heater is a noncontinuous load when calculating a feeder or service. Add noncontinuous loads to the calculation at 100%.

Ⓑ Add lines 3 through 14 to find the minimum volt-ampere load (lines 4, 6, and 11 are blank).

Warning

Although, under normal conditions, a water heater is not considered a continuous load when calculating a feeder or service, it must be considered a continuous load when calculating the branch circuit. The branch circuit overcurrent device and conductors for fixed storage-type water heaters that have a capacity of 120 gal (450 L) or less shall be sized not smaller than 125% of the rating of the water heater »*422.13*«.

14 All Other Loads. *Add all other noncontinuous loads into the calculation at 100%.* *Multiply all other continuous loads (operating for 3 hours or more) by 125%.*	**14**	Ⓐ 2000
15 Total Volt-Ampere Demand Load: *Add lines 3 through 14 to find the minimum required volt-amperes.*	**15**	42,800 Ⓑ

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Lines 16 and 17

Ⓐ Insert the volt-ampere load from line 15 on this line.

Ⓑ The total voltage for a 480-volt, 3-phase system is 831 (480 × 1.732).

Ⓒ The minimum ampacity for a 480-volt, 3-phase service is 52 amperes.

Ⓓ The next-higher standard size fuse (or breaker) above 52 amperes is 60 »*Table 240.6(A)*«.

16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	Ⓐ 42,800 (line 15) ÷ Ⓑ 831 (voltage) =	**16**	Ⓒ 52 (minimum amperes)	**Minimum Size 17 Service or Feeder *240.6(A)***	**17**	Ⓓ 60

Line 18

Ⓐ The minimum 60/75°C (140/167°F) copper service conductor is 6 AWG »*Table 310.16*«.

Ⓑ The minimum 60/75°C (140/167°F) aluminum service conductor is 4 AWG »*Table 310.16*«.

18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	**18**	Ⓐ 6 Cu Ⓑ 4 Al

Line 19

Ⓐ Although there will be little (if any) load on the neutral, a neutral conductor is required. Where an ac system (operating at less than 1000 volts) is grounded at any point, the grounded conductor(s) shall be routed with the ungrounded conductors to each service disconnecting means and shall be connected to each disconnecting means grounded conductor(s) terminal or bus »*250.24(D)*«.

Ⓑ The grounded conductor for services shall not be smaller than specified in Table 250.102(C)(1) »*250.24(D)(1)*«.

Ⓒ In accordance with Table 250.102(C)(1), the minimum size grounded conductor for 2 AWG (or smaller) copper ungrounded conductors is 8 AWG copper.

Ⓓ In accordance with Table 250.102(C)(1), the minimum size grounded conductor for 1/0 AWG (or smaller) aluminum ungrounded conductors is 6 AWG aluminum.

Note

Section 215.2(B) states that the grounded conductor for feeders shall not be smaller than specified in Table 250.122.

Ⓐ **19** Size the Neutral Conductor. *220.61* *The neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, but not smaller than the maximum unbalanced load determined by Article 220. 250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1). A further demand factor is permitted for any neutral load over 200 amperes.*	Ⓑ **Minimum Size Neutral Conductor**	**19**	Ⓒ 8 Cu Ⓓ 6 Al

Line 20

Ⓐ The grounding electrode conductor's size is based on the service-entrance conductor »*Table 250.66*«.

Ⓑ The minimum size copper grounding conductor is 8 AWG.

Ⓒ The minimum size aluminum grounding conductor is 6 AWG.

Ⓐ **20** Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	**20**	Ⓑ 8 Cu Ⓒ 6 Al

The following page shows the store's completed load calculation.

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Nondwelling Feeder/Service Load Calculation

1 Receptacle Load (noncontinuous) *220.14(I)* *Multiply each single or multiple receptacle on one strap by 180 volt-amperes.* *Multiply each single piece of equipment comprised of four or more receptacles by 90 VA per receptacle.*		1	1800
2 Fixed Multioutlet Assemblies (noncontinuous) *220.14(H)* *Where not likely to be used simultaneously, multiply each 5-ft section by 180 volt-amperes.* *Where likely to be used simultaneously, multiply each 1-ft section by 180 volt-amperes.*		2	----
3 Receptacle Load Demand Factor (for nondwelling receptacles) *220.47* *If the receptacle load is more than 10,000 volt-amperes, apply the demand factor from Table 220.47.* *Add lines 1 and 2. Multiply the first 10 kVA or less by 100%. Then multiply the remainder by 50%.*		3	1800
4 Receptacle Load (office buildings only) *220.14(J)* *(1) Calculate the demand in line 3; (2) multiply 1 volt-ampere per square foot and add to line 4; and (3) compare lines 3 and 4 and omit the smaller.*	1 × ---- (sq-ft outside dimensions) =	4	----
5 General Lighting Load *Table 220.42(A). Multiply the VA unit load (for the type of occupancy) by the square-foot outside dimensions. This table already includes the additional 25% for continuous loads.*	1.9 (VA unit load) × 1200 (sq-ft outside dimensions) =	5	2280
6 Lighting Load Demand Factors *220.45. Apply Table 220.45 demand factors to certain portions of hotels, motels, apartment houses (without provisions for cooking), and storage warehouses.* *Do not include areas in hotels and motels where the entire lighting will be used at one time.*		6	----
7 Track Lighting (in addition to general lighting) *220.46(B)* *Include 150 volt-amperes for every 2 ft, or fraction thereof, of lighting track. (Do not include track lighting in guest rooms or suites of hotels or motels.)*	80 (total linear ft) ÷ 2 40 × 150 =	7	6000
8 Sign or Outline Lighting Outlet (where required) *220.14(F)* *Each commercial building (or occupancy) accessible to pedestrians must have at least one outlet per tenant space entrance. 600.5(A) Each outlet must be at least 1200 volt-amperes.*		8	3480
9 Show-Window Lighting *220.46(A)* *Include at least 200 volt-amperes for each linear foot, measured horizontally along the show window's base.*	32 (total linear ft of show window) × 200 =	9	6400
10 Continuous Loads *215.2(A)(1), 215.3,* and *230.42(A)(1)* *Multiply the continuous load volt-amperes (listed above) by 25%.* *(General-purpose receptacles are not considered continuous.)*	15,880 (total continuous load volt-amperes) × 25% =	10	3970
11 Kitchen Equipment *220.56* *Multiply three or more pieces of equipment by the Table 220.56 demand factor (%).* Use *Table 220.55* for household cooking equipment used in instructional programs. *Table 220.55,* Note 7		11	----
12 Noncoincident Loads *220.60. The smaller of two (or more) noncoincident loads can be omitted, as long as they will never be energized simultaneously (such as certain portions of heating and A/C systems).* *Calculate fixed electric space-heating loads at 100% of the total connected load. 220.51*		12	16,496
13 Motor Loads *220.11(A), 220.50, 430.24, 430.25, 430.26,* and Part IV of *Article 440* *Multiply the largest motor (one motor only) by 25% and add it to the load.* *If 25% of the largest motor is in line 12, leave line 13 blank.*		13	374
14 All Other Loads. *Add all other noncontinuous loads into the calculation at 100%.* *Multiply all other continuous loads (operating for 3 hours or more) by 125%.*		14	2000
15 Total Volt-Ampere Demand Load: *Add lines 3 through 14 to find the minimum required volt-amperes.*		15	42,800
16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	42,800 (line 15) ÷ 831 (voltage) = **16** 52 (minimum amperes)		
	17 Minimum Size Service or Feeder *240.6(A)*	17	60
18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	18	6 Cu 4 Al
19 Size the Neutral Conductor. *220.61* *The neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, but not smaller than the maximum unbalanced load determined by Article 220. 250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1). A further demand factor is permitted for any neutral load over 200 amperes.*	**Minimum Size Neutral Conductor**	19	8 Cu 6 Al
20 Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	20	8 Cu 6 Al

Sample Load Calculation—Office Building

Load Calculation Information

Ⓐ Use the information below to calculate the service load of this office building.

A
MILLER BUILDNG

Office building's outside dimensions	**50′ × 100′**
Actual inside connected lighting load	**unknown**
Receptacles	**unknown**
Sign	**9 amperes, 120 volt**
Show window	**none**
Parking lot lighting	**22 amperes, 120 volt**
Water heater	**5 kW, 240 volt**
Electric heating unit #1	**10 kW, 240 volt**
Electric heating unit #2	**10 kW, 240 volt**
Air handler (blower motor) #1	**3.4 amperes, 120 volt**
Air handler (blower motor) #2	**3.4 amperes, 120 volt**
Air-conditioner compressor #1	**14.5 amperes, 240 volt**
Air-conditioner compressor #2	**14.5 amperes, 240 volt**
Condenser fan motor #1	**2 amperes, 120 volt**
Condenser fan motor #2	**2 amperes, 120 volt**

Assume water heater and electric heat kW ratings equivalent to kVA.

The electric supply consists of a 120/240-volt, single-phase, 3-wire service.

The water heater is not a storage-type water heater.

Note

Because the actual number of receptacles is unknown, line 1 does not contain a number.

Line 2 will not contain a number since the office building has no fixed multioutlet assemblies.

Lines 3 and 4

Ⓐ Since lines 1 and 2 are blank, line 3 also does not contain a number. A dashed line has been drawn in line 3 showing that it has been left blank intentionally.

Ⓑ An office building with an unknown number of general-purpose receptacle outlets requires a rating of 1 volt-ampere per square foot.

Ⓒ Since the office building is 5000 ft² (50 × 100), the receptacle load is 5000 volt-amperes.

Ⓐ

3	Receptacle Load Demand Factor (for nondwelling receptacles) *220.47* *If the receptacle load is more than 10,000 volt-amperes, apply the demand factor from Table 220.47. Add lines 1 and 2. Multiply the first 10 kVA or less by 100%. Then multiply the remainder by 50%.*	**3**	----
4	Receptacle Load (office buildings only) *220.14(J)* *(1) Calculate the demand in line 3; (2) multiply 1 volt-ampere per square foot and add to line 4; and (3) compare lines 3 and 4 and omit the smaller.* 1 × 5000 (sq-ft outside dimensions) =	**4**	5000

Ⓑ Ⓒ

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Lines 5 and 6

Ⓐ The volt-ampere unit load for an office building is 1.3 »*Table 220.42(A)*«.

Ⓑ This office building, with outside dimensions of 50 ft × 100 ft, has a total calculated area of 5000 ft^2.

Ⓒ The 125% multiplier for a continuous load as specified in 210.20(A) is included when using the unit loads in Table 220.42(A) for calculating the minimum lighting load for a specified occupancy »*Note to Table 220.42(A)*«. When the load calculation includes the use of volt-ampere unit loads from Table 220.42(A), do not increase this load by the additional 25%.

Ⓓ Because line 6 does not apply to this occupancy, a dashed line has been drawn showing that it has been left blank intentionally.

Note

Because this office building has no lighting track, calculating line 7 is not necessary.

The actual connected lighting load, excluding exterior lighting, is unknown. Table 220.42(A) requires a minimum lighting load of 6500 volt-amperes (1.3 × 5000 = 6500).

In this example, the general lighting load is unknown. Use the actual connected lighting load (if any) only when it is greater than the value computed from Table 220.42(A).

Actual lighting loads are continuous and must be increased by 25%. This function is performed in line 10 as a separate calculation.

5	General Lighting Load *Table 220.42(A). Multiply the VA unit load (for the type of occupancy) by the square-foot outside dimensions. This table already includes the additional 25% for continuous loads.*	Ⓐ 1.3 (VA unit load) × Ⓑ 5000 (sq-ft outside dimensions) =	**5**	Ⓒ 6500
6	Lighting Load Demand Factors *220.45. Apply Table 220.45 demand factors to certain portions of hotels, motels, apartment houses (without provisions for cooking), and storage warehouses. Do not include areas in hotels and motels where the entire lighting will be used at one time.*		**6**	---- Ⓓ

Line 8

Ⓐ Although the office building's actual sign load is 1080 volt-amperes (9 × 120 = 1080), each sign outlet must have a minimum rating of 1200 volt-amperes. Use the actual sign or outline load(s) only if the rating is greater than the required minimum.

Ⓑ This office building's sign load is continuous. Therefore, the rating is part of the continuous volt-ampere load calculation (line 10).

Note

Because this office building has no show window, a show-window lighting load (line 9) is not required.

8	Sign or Outline Lighting Outlet (where required) *220.14(F)* *Each commercial building (or occupancy) accessible to pedestrians must have at least one outlet per tenant space entrance. 600.5(A) Each outlet must be at least 1200 volt-amperes.*	**8**	Ⓐ 1200 Ⓑ

Line 10

Ⓐ This office building's continuous loads are found on line 8. Because the unit load in Table 220.42(A) was used for calculating the minimum lighting load, do not include the number on line 5 with the continuous loads in line 10.

Ⓑ Sign = 1200

Ⓒ An additional 25% volt-ampere load is added to the calculation because of the continuous loads.

Note

Line 11 contains a dashed line because there is no kitchen equipment.

10	Ⓐ Continuous Loads *215.2(A)(1), 215.3,* and *230.42(A)(1)* *Multiply the continuous load volt-amperes (listed above) by 25%. (General-purpose receptacles are not considered continuous.)*	Ⓑ 1200 (total continuous load volt-amperes) Ⓒ × 25% =	**10**	300

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Lines 12 and 13

Each air handler (blower motor) has a rating of 408 volt-amperes (3.4 × 120 = 408). Since the heat and the blower are energized simultaneously, add the air handler to the 10 kW of electric heat. The heating load for each unit is 10,408 volt-amperes (10,000 + 408 = 10,408). The total heating load for this office building is 20,816 volt-amperes (10,408 + 10,408 = 20,816).

Each air-conditioner compressor motor has a rating of 4350 volt-amperes (14.5 × 240 × 125% = 4350). Each condenser fan motor has a rating of 240 volt-amperes (2 × 120 = 240). Each air handler (blower motor) has a rating of 408 volt-amperes (3.4 × 120 = 408). The air-conditioning load for each unit is 4998 volt-amperes (4350 + 240 + 408 = 4998).

The total air-conditioning load for this office building is 9996 volt-amperes (4998 + 4998 = 9996). Because this total is less than the heating load, omit the air-conditioner compressor and the condenser fan motor.

Ⓐ Because the combined electric heat and air-handler load is larger than the combined compressor, condenser fan motor, and air handler, omit the compressor and condenser fan motor load.

Ⓑ Find the largest motor. In this example, it is the blower motor (3.4 × 120 = 408). Increase the largest motor by 25% (408 × 25% = 102).

Ⓐ

12 Noncoincident Loads *220.60. The smaller of two (or more) noncoincident loads can be omitted, as long as they will never be energized simultaneously (such as certain portions of heating and A/C systems). Calculate fixed electric space-heating loads at 100% of the total connected load. 220.51*	**12**	20,816
13 Motor Loads *220.11(A), 220.50, 430.24, 430.25, 430.26,* and Part IV of *Article 440* *Multiply the largest motor (one motor only) by 25% and add it to the load.* *If 25% of the largest motor is in line 12, leave line 13 blank.*	**13**	102

Ⓑ

Lines 14 and 15

Ⓐ At this point, two loads have not been calculated: one continuous and one noncontinuous load. Because parking-lot lighting is continuous, multiply by 125% (22 × 120 × 125% = 3300 volt-amperes). The water heater is a noncontinuous load. These two loads have a combined total rating of 8300 volt-amperes (3300 + 5000 = 8300).

Ⓑ Add lines 3 through 14 to determine the minimum volt-ampere load (lines 3, 6, 7, 9, and 11 are blank).

Ⓐ

14 All Other Loads. *Add all other noncontinuous loads into the calculation at 100%.* *Multiply all other continuous loads (operating for 3 hours or more) by 125%.*	**14**	8300
15 Total Volt-Ampere Demand Load: *Add lines 3 through 14 to find the minimum required volt-amperes.*	**15**	42,218

Ⓑ

Lines 16 and 17

Ⓐ Insert the total volt-ampere demand load from line 15.

Ⓑ Divide the volt-amperes by the voltage to find the amperage for the load calculation. The amperage is 176 amperes (42,218 ÷ 240 = 175.9 = 176). In accordance with 220.5(B), fractions of an ampere 0.5 and higher are rounded up, while fractions less than 0.5 are dropped.

Ⓒ The minimum amperes for the service supplying this office building is 176 amperes.

Ⓓ The next higher standard size fuse (or breaker) above 176 amperes is 200 »*Table 240.6(A)*«.

Ⓐ Ⓑ Ⓒ Ⓓ

16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	42,218 (line 15)	÷	240 (voltage)	=	**16**	176 (minimum amperes)	**17** **Minimum Size Service or Feeder** ***240.6(A)***	**17**	200

Line 18

Ⓐ The minimum 75°C (167°F) copper service conductor is 3/0 AWG »*Table 310.16*«.

Ⓑ The minimum 75°C (167°F) aluminum service conductor is 4/0 AWG »*Table 310.16*«.

Ⓐ

18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size. If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	**18**	3/0 Cu 4/0 Al

Ⓑ

Line 19

Ⓐ The neutral conductor calculation requires only loads having a neutral or grounded conductor termination. In this example, include lines 4, 5, 8, and parts of lines 12 and 14. Line 12's neutral load calculation is 816 volt-amperes (3.4 × 120 × 2 = 816). Line 14's neutral load calculation is 2640 volt-amperes (22 × 120 = 2640). The total neutral load is 16,156 volt-amperes (5000 + 6500 + 1200 + 816 + 2640 = 16,156). The minimum required neutral rating is 67 amperes (16,156 ÷ 240 = 67.3 = 67).

Ⓑ The minimum 75°C (167°F) copper neutral conductor is 4 AWG »*Table 310.16*«. In accordance with 250.24(D)(1), the grounded conductor shall not be smaller than specified in Table 250.102(C)(1). In this example, the copper-neutral conductor selected is in compliance with the minimum required sizes in Table 250.102(C)(1).

Ⓒ The minimum 75°C (167°F) aluminum neutral conductor is 3 AWG. However, this conductor size does not meet the minimum requirements in Table 250.102(C)(1), so a 2 AWG aluminum neutral conductor is required. »*Table 310.16* and *Table 250.102(C)(1)*«.

Note

Grounded conductors that are not connected to an overcurrent device shall be permitted to be sized at 100% of the sum of the continuous and noncontinuous load »***230.42(A)(1) Exception No. 1* and *215.2(A)(1) Exception No. 3***«.

Ⓐ Ⓑ

19 Size the Neutral Conductor. *220.61* *The neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, but not smaller than the maximum unbalanced load determined by Article 220. 250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1). A further demand factor is permitted for any neutral load over 200 amperes.*	**Minimum Size Neutral Conductor**	**19**	4 Cu 2 Al

Ⓒ

Line 20

Ⓐ The grounding electrode conductor's size is based on the service-entrance conductor »*Table 250.66*«.

Ⓑ The minimum size copper grounding conductor is 4 AWG.

Ⓒ The minimum size aluminum grounding conductor is 2 AWG.

Ⓐ Ⓑ

20 Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122. Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	**20**	4 Cu 2 Al

Ⓒ

The following page shows the office building's completed load calculation.

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Nondwelling Feeder/Service Load Calculation

1 Receptacle Load (noncontinuous) *220.14(I)* *Multiply each single or multiple receptacle on one strap by 180 volt-amperes.* *Multiply each single piece of equipment comprised of four or more receptacles by 90 VA per receptacle.*		1	----
2 Fixed Multioutlet Assemblies (noncontinuous) *220.14(H)* *Where not likely to be used simultaneously, multiply each 5-ft section by 180 volt-amperes.* *Where likely to be used simultaneously, multiply each 1-ft section by 180 volt-amperes.*		2	----
3 Receptacle Load Demand Factor (for nondwelling receptacles) *220.47* *If the receptacle load is more than 10,000 volt-amperes, apply the demand factor from Table 220.47.* *Add lines 1 and 2. Multiply the first 10 kVA or less by 100%. Then multiply the remainder by 50%.*		3	----
4 Receptacle Load (office buildings only) *220.14(J)* *(1) Calculate the demand in line 3; (2) multiply 1 volt-ampere per square foot and add to line 4; and (3) compare lines 3 and 4 and omit the smaller.*	1 × 5000 (sq-ft outside dimensions) =	4	5000
5 General Lighting Load *Table 220.42(A). Multiply the VA unit load (for the type of occupancy) by the square-foot outside dimensions. This table already includes the additional 25% for continuous loads.*	1.3 (VA unit load) × 5000 (sq-ft outside dimensions) =	5	6500
6 Lighting Load Demand Factors *220.45. Apply Table 220.45 demand factors to certain portions of hotels, motels, apartment houses (without provisions for cooking), and storage warehouses.* *Do not include areas in hotels and motels where the entire lighting will be used at one time.*		6	----
7 Track Lighting (in addition to general lighting) *220.46(B)* *Include 150 volt-amperes for every 2 ft, or fraction thereof, of lighting track. (Do not include track lighting in guest rooms or suites of hotels or motels.)*	---- (total linear ft) ÷ 2 ---- × 150 =	7	----
8 Sign or Outline Lighting Outlet (where required) *220.14(F)* *Each commercial building (or occupancy) accessible to pedestrians must have at least one outlet per tenant space entrance. 600.5(A) Each outlet must be at least 1200 volt-amperes.*		8	1200
9 Show-Window Lighting *220.46(A)* *Include at least 200 volt-amperes for each linear foot, measured horizontally along the show window's base.*	---- (total linear ft of show window) × 200 =	9	----
10 Continuous Loads *215.2(A)(1), 215.3,* and *230.42(A)(1)* *Multiply the continuous load volt-amperes (listed above) by 25%.* *(General-purpose receptacles are not considered continuous.)*	1200 (total continuous load volt-amperes) × 25% =	10	300
11 Kitchen Equipment *220.56* *Multiply three or more pieces of equipment by the Table 220.56 demand factor (%).* Use *Table 220.55* for household cooking equipment used in instructional programs. *Table 220.55,* Note 7		11	----
12 Noncoincident Loads *220.60. The smaller of two (or more) noncoincident loads can be omitted, as long as they will never be energized simultaneously (such as certain portions of heating and A/C systems).* *Calculate fixed electric space-heating loads at 100% of the total connected load. 220.51*		12	20,816
13 Motor Loads *220.11(A), 220.50, 430.24, 430.25, 430.26,* and Part IV of *Article 440* *Multiply the largest motor (one motor only) by 25% and add it to the load.* *If 25% of the largest motor is in line 12, leave line 13 blank.*		13	102
14 All Other Loads. *Add all other noncontinuous loads into the calculation at 100%.* *Multiply all other continuous loads (operating for 3 hours or more) by 125%.*		14	8300
15 Total Volt-Ampere Demand Load: *Add lines 3 through 14 to find the minimum required volt-amperes.*		15	42,218
16 Minimum Amperes *Divide the total volt-amperes by the voltage.*	42,218 (line 15) ÷ 240 (voltage) = **16** 176 (minimum amperes) **17** **Minimum Size Service or Feeder *240.6(A)***	17	200
18 Size the Service or Feeder Conductors. *Tables 310.16* through *310.21* *Use the tables along with 310.15(A) through (F) to determine conductor size.* *If the overcurrent device is rated more than 800 amperes, the conductor ampacity must be equal to, or greater than, the rating of the overcurrent device. 240.4(C)*	**Minimum Size Conductors**	18	3/0 Cu 4/0 Al
19 Size the Neutral Conductor. *220.61* *The neutral service or feeder conductor can be smaller than the ungrounded (hot) conductors, but not smaller than the maximum unbalanced load determined by Article 220. 250.24(D)(1) states that the grounded conductor shall not be smaller than specified in Table 250.102(C)(1). A further demand factor is permitted for any neutral load over 200 amperes.*	**Minimum Size Neutral Conductor**	19	4 Cu 2 Al
20 Size the Grounding Electrode Conductor (for Service). *250.66* *Use line 18 to find the grounding electrode conductor in Table 250.66.* Size the Equipment Grounding Conductor (for Feeder). *250.122* *Use line 17 to find the equipment grounding conductor in Table 250.122.* *Equipment grounding conductor types are listed in 250.118.*	**Minimum Size Grounding Electrode Conductor . . . *or* . . . Equipment Grounding Conductor**	20	4 Cu 2 Al

Summary

- Article 220 contains load calculation procedures for nondwelling units.
- Unlike dwelling unit load calculations, receptacle outlets must be included.
- Receptacle loads, including fixed multioutlet assemblies, can be derated if the load is greater than 10,000 volt-amperes.
- If the actual number of receptacle outlets in an office building is unknown, a load of 1 volt-ampere per square foot must be included.
- Various occupancy types have different volt-ampere unit loads per Table 220.42(A).
- One similarity between dwelling unit and nondwelling unit load calculations is that a volt-ampere unit load must be multiplied by the square footage using outside dimensions.
- Table 220.45 contains lighting load demand factors for certain portions of hotels, motels, storage warehouses, and apartment houses without provisions for cooking.
- Track lighting loads must be included in addition to the general lighting load for other than dwelling units, hotels, or motels.
- Some occupancies require a sign or outline lighting outlet.
- Show-window minimum volt-ampere lighting loads are based on a linear footage measurement.
- Continuous load calculations must be increased by an additional 25% volt-ampere rating.
- The volt-ampere rating, calculated in accordance with Article 220, represents only the minimum rating.
- A list of standard ampere ratings for fuses and inverse time circuit breakers is in Table 240.6(A).

Unit 13 Competency Test

NEC® Reference	Answer	
____________	____________	1. What is the demand load contribution for a commercial laundry with ten 5-kVA clothes dryers and ten 1.5-kVA washing machines?
____________	____________	2. What is the volt-ampere unit load per square foot for the lighting of a beauty salon?
____________	____________	3. Outlets for heavy-duty lampholders shall be calculated at a minimum of ____________ volt-amperes.
____________	____________	4. What is the minimum general lighting load for an 11,750-ft^2 nightclub with an actual connected lighting load of 14,060 volt-amperes?
____________	____________	5. A restaurant contains the following commercial kitchen equipment: two 12-kW ovens, one 10-kW grill, two 8-kW deep fryers, one 1.2-kW disposer, one 1.5-kW dishwasher, one 10-kW booster heater, and one 4.5-kW water heater. What is the minimum calculated feeder load (in kW) for this equipment?
____________	____________	6. For track lighting in a church, a load of not less than ____________ shall be included for every ____________ ft of lighting track or fraction thereof.
____________	____________	7. What is the minimum calculated branch-circuit load for 52 duplex receptacle outlets installed in a 9600-ft^2 office building?
____________	____________	8. Where it is unlikely that two or more ____________ loads will be in use simultaneously, it shall be permissible to use only the largest load(s) that will be used at one time in calculating the total load of a feeder or service.
____________	____________	9. What is the minimum calculated service load for 250 receptacle outlets installed in an office building?
____________	____________	10. What is the minimum calculated branch-circuit lighting load for an 8000-ft^2 auditorium?
____________	____________	11. A manufacturing plant has 320 ft of multioutlet assemblies, of which 60 ft will contain equipment subject to simultaneous use. What is the minimum calculated service load for these multioutlet assemblies?

***NEC*® Reference** **Answer**

____________ ____________ 12. A school home economics classroom has twelve 8-kW household ranges. This kitchen equipment is supplied by a 240-volt, single-phase panelboard. What minimum size THW copper conductors are required for this feeder?

____________ ____________ 13. A motel has 50 guest rooms, each room measuring 18 ft × 30 ft. Each room contains eight duplex receptacles, of which one is GFCI protected. What is the minimum calculated service load for the lighting and receptacle outlets for the guests rooms in this motel?

____________ ____________ 14. What is minimum calculated branch-circuit load for the show-window lighting for a retail store that has 40 linear feet of show windows?

____________ ____________ 15. An outlet supplying recessed luminaire(s) shall be calculated based on ____________.

____________ ____________ 16. For circuits supplying loads consisting of motor-operated utilization equipment that is fastened in place and that has a motor larger than ⅛ hp in combination with other loads, the total calculated load shall be based on ____________.

____________ ____________ 17. In a commercial storage garage, duplex receptacle outlets shall be computed at not less than ____________.

____________ ____________ 18. A restaurant contains the following commercial kitchen equipment: one 12-kW range, one 2.8-kW mixer, one 4.2-kW deep fryer, two 0.8-kW soup wells, and one 6-kW water heater. What is the feeder demand load (in kW) for this equipment?

____________ ____________ 19. A hospital has 150 patient's rooms, each room measuring 15 ft × 25 ft. What is the general lighting load (after demand factors) for these rooms? Lighting outlets in these rooms may be energized for more than three hours at a time.

____________ ____________ 20. For circuits supplying lighting units that have ballasts, transformers, autotransformers, or LED drivers, the calculated load shall be based on ____________.

Questions 21 through 30 are based on an office containing the following:

Office's total sq-ft area	19,000 ft^2
Receptacle outlets	200
Multioutlet assemblies	80 ft
Multioutlet assemblies (simultaneously used)	25 ft
Sign	15 amperes, 120 volt
Track lighting	48 ft
Water heater	5 kW, 208 volt
Four electric heating units	10 kW, 208 volt (each)
Four air handlers (blower motors)	4 amperes, 208 volt, 3-phase (each)
Four air-conditioner compressors	19.6 amperes, 208 volt, 3-phase (each)
Four condenser fan motors	3 amperes, 208 volt, 3-phase (each)

Assume water heater and electric heat kW ratings equivalent to kVA.

The electric supply is a 208-volt, 3-phase, 4-wire service.

____________ ____________ 21. What is the total receptacle (including multioutlet assembly) volt-ampere service load after demand factors are applied?

____________ ____________ 22. What is the minimum calculated branch-circuit lighting load for this 19,000-ft^2 office?

____________ ____________ 23. What is the minimum calculated service load for the track lighting if the lighting will be noncontinuous?

***NEC*® Reference**	**Answer**	
		24. What is the minimum calculated branch-circuit load for the sign? (For this question, do not apply the continuous load demand factor.)
		25. Which load(s), if any, can be omitted from the service calculation?
		26. What is the minimum calculated service load for the heating and air-conditioning equipment?
		27. What is the minimum size service overcurrent protective device required for this office?
		28. A parallel run (two sets) of service-entrance conductors will be installed in two raceways. What is the minimum size THWN copper ungrounded conductors that can be used?
		29. What is the minimum size THWN copper neutral (grounded) conductors that can be installed?
		30. What is the minimum size copper grounding electrode conductor?

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Unit 14

Section Four: Commercial Locations

Services, Feeders, and Equipment

Objectives

After studying this unit, the student should be able to:

- identify the required minimum vertical wiring clearances for each electrical installation.
- recall that other associated equipment, above or below the electrical installation, shall not extend more than 6 in. (150 mm) beyond the front of that electrical equipment.
- summarize the dedicated space above and below panelboards, switchboards, switchgear, and motor control centers.
- recall that a space equal to the equipment's width and depth, above panelboards, switchboards, switchgear, and motor control centers, must be clear of foreign systems unless protection is provided.
- explain how working space clearances vary depending on the conditions and voltages.
- identify the conditions that require two equipment working space entrances.
- explain where to connect grounded and grounding conductors on both the service supply side and load side.
- clarify the conditions that require ground-fault protection of equipment.
- summarize separately derived system provisions for transformers and generators.
- explain why grounding and bonding connection points shall be made in the same place, at either the panel or the transformer.
- summarize general installation provisions and vertical installation provisions for busways.
- identify the information that is required on an arc flash hazard warning label.

Introduction

Unit 14 contains electrical provisions relative to commercial type occupancies. Before beginning this unit, a review of Unit 9—Services and Electrical Equipment is recommended. Some of the same provisions that apply to one-family dwellings likewise apply to commercial installations. Vertical wiring clearances, found in Articles 225 and 230, apply to all electrical feeder and service installations. Also applicable to both dwelling and commercial areas is 110.26, which contains minimum working space provisions (1000 volts or less) above, below, and in front of electrical equipment. Some requirements, such as for equipment rated 1200 amperes or more, over 6 ft (1.8 m) wide, and containing devices (overcurrent, switching, or control), are not included in Unit 9. This unit contains separately derived system provisions that pertain to certain battery, solar photovoltaic, generator, transformer, and converter winding-system installations. Because of space limitations, only transformer illustrations are used to explain these provisions. In addition to the separately derived system provisions, transformers have their own article (450). Although there are some exceptions, Article 450 covers the installation of all transformers see (450.1). Following the transformer material is an illustration briefly touching on generator provisions. Although generators have their own article (445), other generator provisions are found throughout the Code. Generators and their associated wiring and equipment must also adhere to applicable provisions of Articles 695, 700, 701, 702, and 705. Busway provisions close this unit. Busways can also be found in multiple occupancy types, that is, multifamily, commercial, and industrial.

Since state and local jurisdictions may modify *NEC*® provisions, it is expedient to obtain a copy of local rules and regulations.

Clearances and Working Space

Vertical Clearances

A 10-ft (3.0-m) minimum vertical clearance is required above finished grade for sidewalks, or from any platform or projection from which overhead service conductors (of 150 volts, or less, to ground) might be reached »*230.24(B)(1)* and *225.18(1)*«.

A minimum 12-ft (3.7-m) vertical clearance is required over commercial areas (not subject to truck traffic) provided conductor voltage does not exceed 300 volts to ground »*230.24(B)(2)* and *225.18(2)*«.

The minimum vertical clearance increases from 12 ft (3.7 m) to 15 ft (4.5 m) for conductors whose voltage exceeds 300 volts to ground »*230.24(B)(3)* and *225.18(3)*«.

A drip loop's lowest point has a minimum vertical clearance of 10 ft (3.0 m)»*230.24(B)(1)*«.

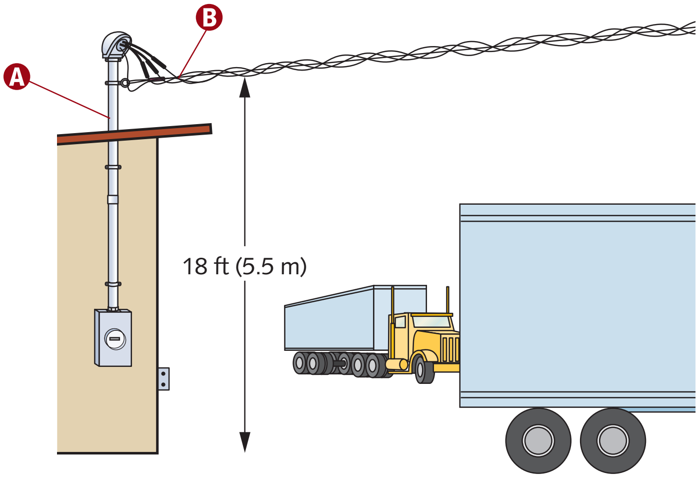
The minimum vertical clearance over track rails of railroads is 24.5 ft (7.5 m) »*230.24(B)(5)* and *225.18(5)*«.

Note

Clearance from communication wires and cables shall be in accordance with 800.44(A)(4) »*230.24(E)*«.

Ⓐ The point of attachment of the service-drop conductors to a building (or other structure) shall meet 230.9 and 230.24 minimum clearance specifications. This point of attachment shall always be at least 10 ft (3.0 m) above finished grade »*230.26*«.

Ⓑ Public streets, alleys, roads, parking areas subject to truck traffic, driveways on nonresidential property, and other land traversed by vehicles (such as cultivated, grazing, forest, and orchard) require a minimum 18-ft (5.5-m) vertical clearance »*230.24(B)(4)* and *225.18(4)*«.



Maximum Depth of Associated Equipment

Ⓐ The depth of the working space in the direction of live parts shall not be less than indicated by Table 110.26(A)(1) »*110.26(A)(1)*«.

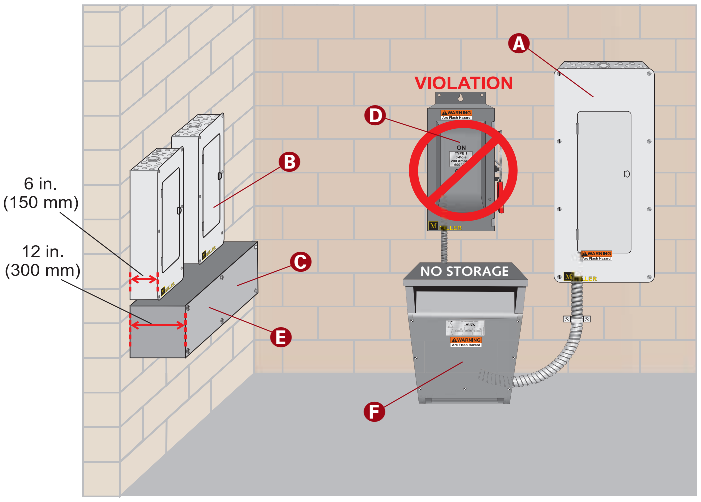
Ⓑ All electrical equipment shall be constantly surrounded by sufficient access and work space permitting ready and safe equipment operation and maintenance »*110.26*«.

Ⓒ Wireways are troughs (sheet metal or nonmetallic) with hinged or removable covers used to house as well as protect electric wires and cables. A wireway shall be installed as a complete system before conductors are laid in place »*Article 100*«.

Ⓓ Within the height requirements of 110.26, other equipment that is associated with the electrical installation and is located above or below the electrical equipment shall not extend more than 6 in. (150 mm) beyond the front of the electrical equipment »*110.26(A)(3)*«.

Ⓔ This trough (wireway) extends 6 in. (150 mm) beyond the front of these panelboards, which is the maximum distance permitted.

Ⓕ This transformer extends more than 6 in. (150 mm) beyond the front of the panelboard and therefore, this installation is not permitted.



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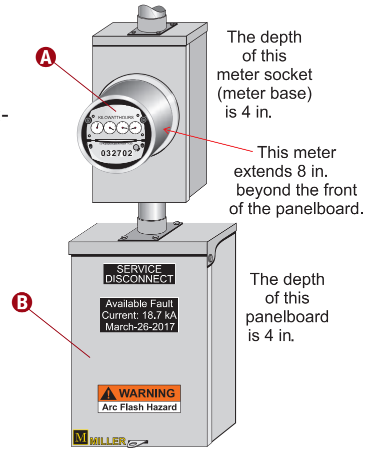
Maximum Depth Exception

A Meters that are installed in meter sockets shall be permitted to extend beyond the other equipment. The meter socket shall be required to follow the rules of 110.26 »*110.26(A)(3) Exception No. 3*«.

B Within the height requirements of 110.26(A)(3), other equipment or support structures, such as concrete pads, that are associated with the electrical installation and are above or below the electrical equipment shall be permitted to extend not more than 6 in. (150 mm) beyond the front of the electrical equipment »*110.26(A)(3)*«.



The depth of this meter socket (meter base) is 4 in.

This meter extends 8 in. beyond the front of the panelboard.

The depth of this panelboard is 4 in.

Equipment Located in a Space with Limited Access

A Where equipment operating at 1000 volts, nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized is required by installation instructions or function to be located in a space with limited access, all of the provisions in 110.26(A)(4)(1) through (4) shall apply »*110.26(A)(4)*«.

B Where equipment is installed above a lay-in ceiling, there shall be an opening not smaller than 22 in. × 22 in. (559 mm × 559 mm) »*110.26(A)(4)(1)*«.

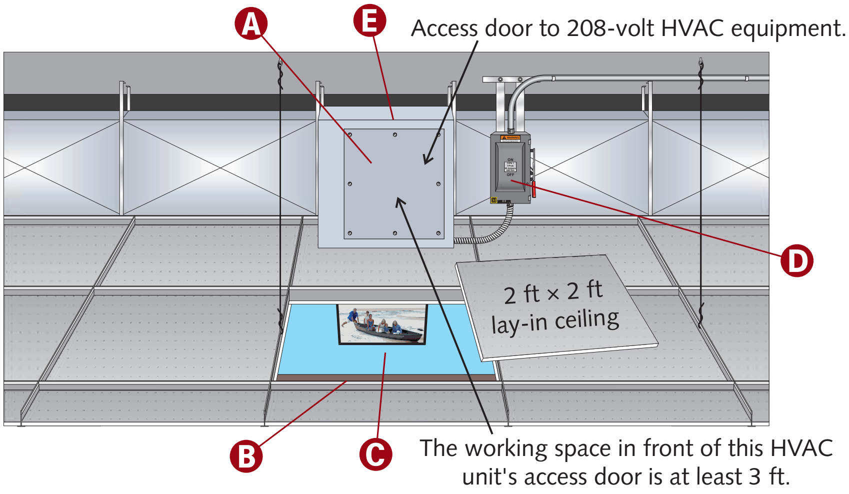
C The width of the working space shall be the width of the equipment enclosure or a minimum of 30 in. (762 mm), whichever is greater »*110.26(A)(4)(2)*«.

D All enclosure doors or hinged panels shall be capable of opening a minimum of 90° »*110.26(A)(4)(3)*«.

E The space in front of the enclosure shall comply with the depth requirements of Table 110.26(A)(1). The maximum height of the working space shall be the height necessary to install the equipment in the limited space. A horizontal ceiling structural member or access panel shall be permitted in this space »*110.26(A)(4)(4)*«.

Note

Limited access space requirements in 110.26(A)(4) also apply to crawl spaces with equipment operating at 1000 volts, nominal, or less to ground and is likely to require examination, adjustment, servicing, or maintenance while energized.



Access door to 208-volt HVAC equipment.

The working space in front of this HVAC unit's access door is at least 3 ft.

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Dedicated Equipment Space—Indoor

Sprinkler protection is permitted for the dedicated space where piping complies with 110.26 »*110.26(E)(1)(c)*«.

A The area above the dedicated space required by 110.26(E)(1)(a) can contain foreign systems, provided protection is installed to avoid damage to the electrical equipment from condensation, leaks, or breaks in such foreign systems »*110.26(E)(1)(b)*«.

B The space equal to the equipment's width and depth extending from the floor to a height of 6 ft (1.8 m) above the equipment or to the structural ceiling (whichever is lower) is dedicated to the electrical installation. No piping, ducts, or foreign equipment shall be located in this zone »*110.26(E)(1)(a)*«.

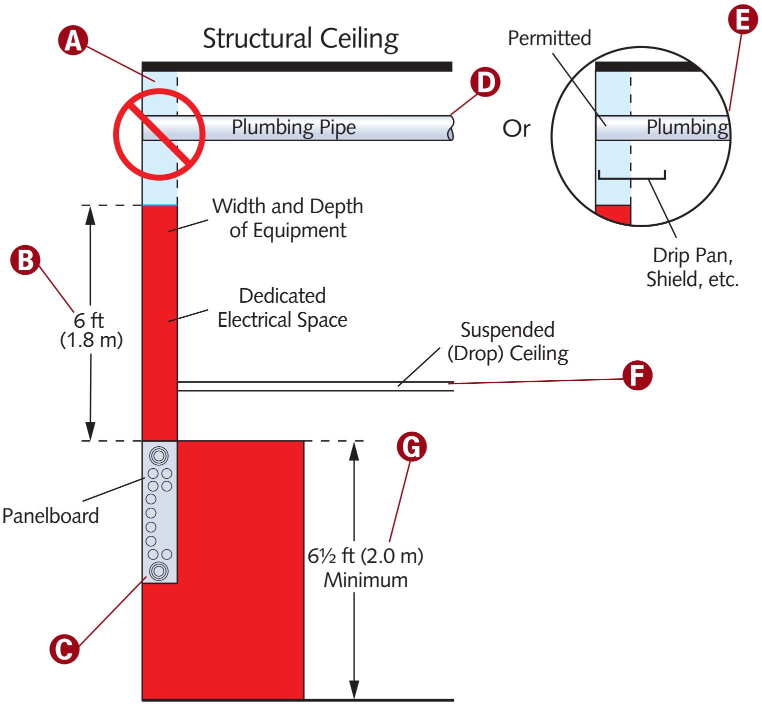
C All switchboards, switchgear, panelboards, and motor control centers shall be located in dedicated spaces and protected from damage »*110.26(E)*«.

D Section 110.26(E)(1)(b) pertains to piping, ducts, etc. that could damage electrical equipment due to condensation, leaks, or breaks.

E Foreign systems may enter the area above the dedicated electrical space if the electrical equipment is protected from condensation, leaks, or breaks in such foreign systems »*110.26(E)(1)(b)*«.

F A dropped, suspended, or similar ceiling not adding strength to the building structure is not a structural ceiling »*110.26(E)(1)(d)*«.

G The work space shall be clear and extend from the grade, floor, or platform to a height of 6½ ft (2.0 m) or the height of the equipment, whichever is greater »*110.26(A)(3)*«.


A
Structural Ceiling
Plumbing Pipe
D
Permitted
Or
E
Plumbing
Drip Pan,
Shield, etc.
Width and Depth
of Equipment
B
6 ft
(1.8 m)
Dedicated
Electrical Space
Suspended
(Drop) Ceiling
F
G
Panelboard
6½ ft (2.0 m)
Minimum
C

Note

Suspended ceilings with removable panels are permitted within the 6-ft (1.8-m) dedicated space »***110.26(E)(1)(a) Exception***«.

Dedicated Equipment Space—Outdoor

Outdoor electrical equipment shall be the following:

1) Installed in identified enclosures

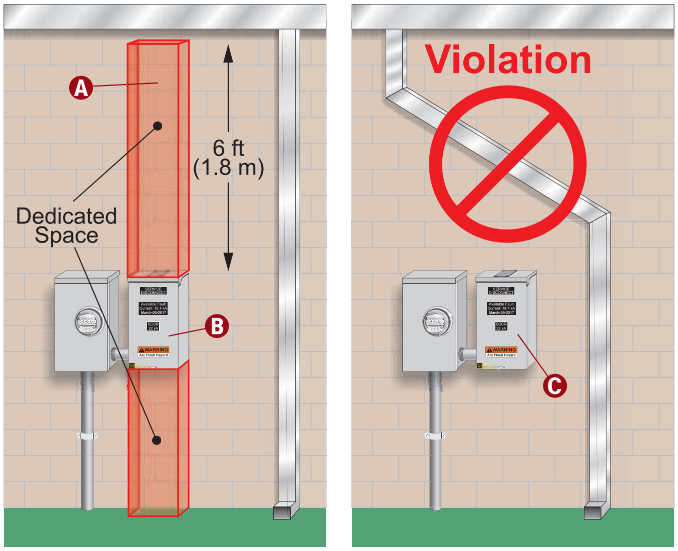
2) Protected from accidental contact by unauthorized personnel or by vehicular traffic

3) Protected from accidental spillage or leakage from piping systems »*110.26(E)(2)(a)*«.

A The space equal to the width and depth of the equipment, and extending from grade to a height of 6 ft (1.8 m) above the equipment, shall be dedicated to the electrical installation. No piping or other equipment foreign to the electrical installation shall be located in this zone »*110.26(E)(2)(c)*«.

B Section 110.26(E)(2) pertains to all switchboards, switchgear, panelboards, and motor control centers installed outdoors.

C The working clearance space shall include the zone described in 110.26(A). No architectural appurtenance or other equipment shall be located in this zone »*110.26(E)(2)(B)*«. Structural overhangs or roof extensions shall be permitted in this zone »*110.26(E)(2) Exception*«.



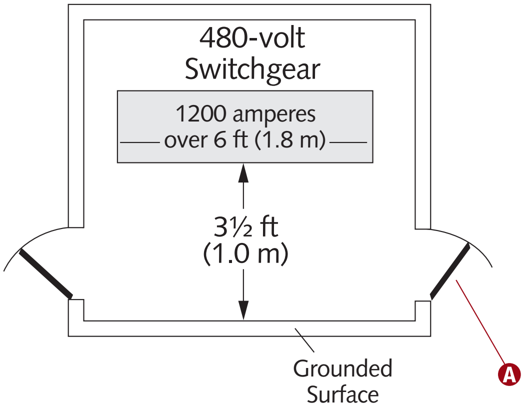
Working Space Access and Entrances

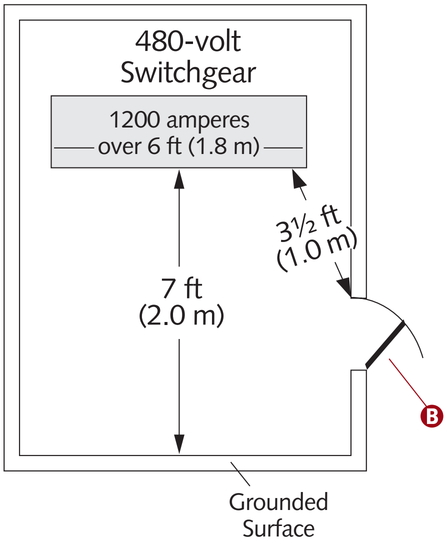
One access means is permitted where the location provides a continuous and unobstructed exit »*110.26(C)(2)(a)*«.

When normally enclosed live parts are exposed for inspection or servicing, any surrounding workspace, in a passageway or general open area, shall be suitably guarded »*110.26(B)*«.

A Equipment rated 1200 amperes (or more) and over 6 ft (1.8 m) wide and service disconnecting means where the combined ampere rating is 1200 amperes or more and over 6 ft (1.8 m) wide containing overcurrent devices, switching devices, or control devices, requires an entrance to and egress from the required working space at least 24 in. (610 mm) wide and 6½ ft (2.0 m) high at each end of the working space »*110.26(C)(2)*«.

B If the workspace specified by 110.26(A)(1) is doubled, only one entrance is required. The edge of the entrance nearest the equipment shall meet the minimum clear distance given in Table 110.26(A)(1) »*110.26(C)(2)(b)*«.





Note

Equipment operating over 1000 volts, nominal, must comply with Article 110, Part III.

Warning

Do not use working space required by 110.26 for storage »*110.26(B)*«.

Caution

Where equipment rated 800 amperes or more that contains overcurrent devices, switching devices, or control devices is installed and there is a personnel door(s) intended for entrance to and egress from the working space less than 25 ft (7.6 m) from the nearest edge of the working space, the door(s) shall open at least 90 degrees in the direction of egress and be equipped with listed panic hardware »*110.26(C)(3)*«.

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Working Space

Condition 1—Exposed live parts on one side of the working space with no live or grounded parts on the other side of the working space, or exposed live parts on both sides of the working space that are effectively guarded by insulating materials »*Table 110.26(A)(1)*«.

A The working space depth in the direction of access to live parts must meet Table 110.26(A)(1) specifications unless the requirements of 110.26(A)(1)(a), (A)(1)(b), or (A)(1)(c) are met. If exposed, measure the distance from the live part(s). Where enclosed, distance measurement begins from the enclosure front (or opening) »*110.26(A)(1)*«.

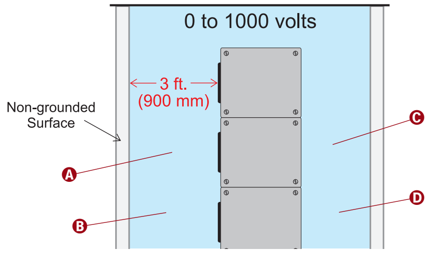
B Sufficient access and working space shall be provided and maintained about all electric equipment, permitting ready, safe equipment operation and maintenance »*110.26*«.

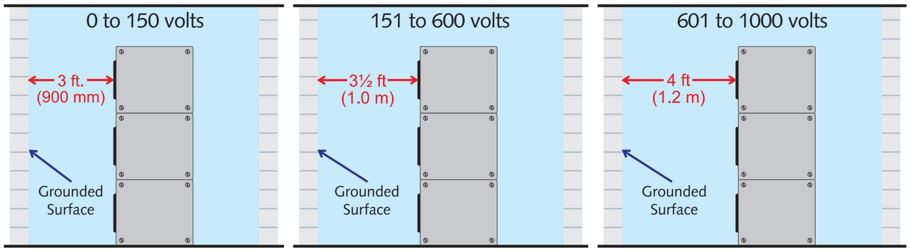
Note

Electrical equipment rooms or enclosures housing electrical apparatus that are controlled by a lock(s) shall be considered accessible to qualified persons ***»110.26(F)«***.

C Working space is not required behind or beside assemblies, such as dead-front switchboards, switchgear, or motor control centers, having no renewable or adjustable parts (such as fuses or switches) on the back or sides, provided all connections are accessible from other locations »*110.26(A)(1)(a)*«.

D Where rear access is required to work on nonelectrical parts at the back of enclosed equipment, a minimum working space of 30 in. (762 mm) horizontally is required »*110.26(A)(1)(a)*«.





Condition 2—Exposed live parts on one side of the working space with grounded parts on the other side. Concrete, brick, or tile walls qualify as grounded »*Table 110.26(A)(1)*«.

Condition 3—Exposed live parts on both sides of the working space »*Table 110.26(A)(1)*«.

In replacing equipment within existing buildings, Condition 2 working clearance is permitted between dead-front switchboards, switchgear, panelboards, or motor control centers located across the aisle from each other where (1) conditions of maintenance and supervision ensure that written procedures have been adopted to prohibit equipment on both sides of the aisle from being open at the same time and (2) authorized qualified personnel will service the installation »*110.26(A)(1)(c)*«.

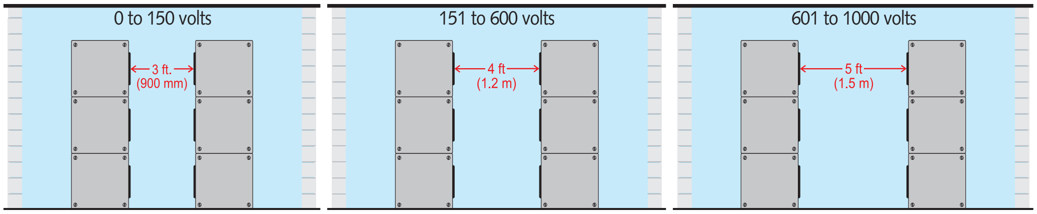
Caution

Working space for equipment operating at 1000 volts, nominal, or less to ground and likely to require examination, adjustment, servicing, or maintenance while energized shall comply with 110.26(A)(1) through (4) dimensions, or as required/permitted elsewhere in the Code »*10.26(A)*«.

Note

By special permission, smaller working spaces are allowed where all exposed live parts are no greater than 30 volts root-mean-square (rms), 42 peak, or 60 volts direct current (dc) ***»110.26(A)(1)(b)«***.

Equipment operating over 1000 volts, nominal, must comply with Article 110, Part III.



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Guarding and Warning

Except as required (or permitted) elsewhere by the *NEC*, live parts of electric equipment operating at 50 to 1000 volts, nominal shall be guarded against accidental contact by approved enclosures or by any of the following means listed in 110.27(A):

1. By location in a room, vault, or similar enclosure accessible only to qualified persons.
2. By permanent, substantial partitions or screens arranged so that only qualified persons have access to the space within reach of the live parts. Any openings in such partitions or screens shall be sized and located so that persons are not likely to come into accidental contact with the live parts or to bring conducting objects into contact with them.
3. By locations on a balcony, gallery, or elevated platform whose arrangement excludes unqualified persons.
4. By elevations above the floor or other working surface as follows:
   a. A minimum of 8 ft (2.5 m) for 50 volts to 300 volts between ungrounded conductors
   b. A minimum of 8-½ ft (2.6 m) for 301 volts to 600 volts between ungrounded conductors
   c. A minimum of 8 ft 7 in. (2.62 m) for 601 volts to 1000 volts between ungrounded conductors

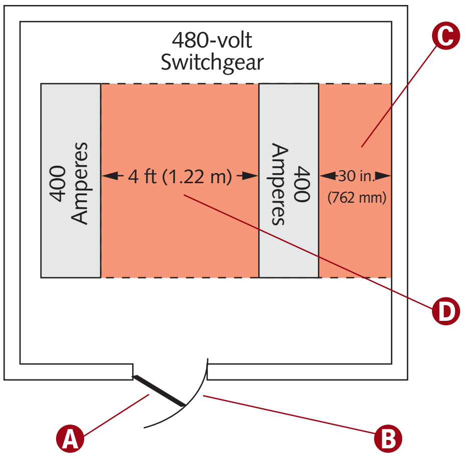
Where potential for physical damage to electric equipment exists, enclosures (or guards) shall be of sufficient strength and placement to prevent such damage »*110.27(B)*«.

Ⓐ At least one entrance of sufficient area shall be provided, giving access to and egress from the electrical equipment's working space »*110.26(C)(1)*«.

Ⓑ Entrances to rooms and other guarded locations containing exposed live parts shall be marked with conspicuous warning signs forbidding entrance of unqualified persons. The marking shall meet the requirements in 110.21(B) »*110.27(C)*«.

Ⓒ When working on nonelectric parts on the back of enclosed equipment requires rear access, a minimum working space of 30 in. (762 mm) horizontally shall be provided »*110.26(A)(1)(a)*«.

Ⓓ This is Condition 3 in Table 110.26(A)(1).

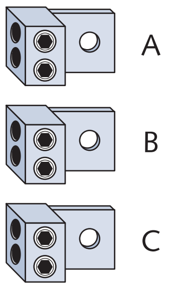


Switchboards, Switchgear, and Panelboards

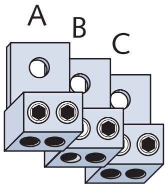
Phase Arrangement

The alternating current phase arrangement on 3-phase busses are A, B, C from front to back, top to bottom, or left to right, as viewed from the front of the switchboard, switchgear, or panelboard. The B phase must be that phase having the higher voltage to ground on 3-phase, 4-wire, delta-connected systems. Other clearly marked busbar arrangements are permitted for existing installation additions »*408.3(E)(1)*«.

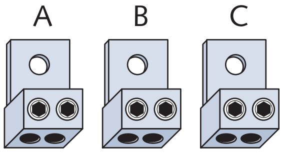
Equipment sharing the same single section or multisectional switchboard, switchgear, or panelboard as the meter (on 3-phase, 4-wire, delta-connected systems) is allowed to have the same phase configuration as the metering equipment »*408.3(E)(1) Exception*«.



Top to Bottom



Front to Back



Left to Right

Note

A switchboard, switchgear, or panelboard supplied from a 4-wire, delta-connected system where the midpoint of one phase winding is grounded, requires the phase busbar or conductor having the higher voltage to ground to be durably and permanently marked by an outer orange finish or by other effective means. Such identification shall be placed at each point on the system where a connection is made if the grounded conductor is also present »*110.15*«.

Caution

The area electric utility company may require a different phase arrangement on 3-phase, 4-wire, delta-connected systems. Obtain a copy of the utility's phase arrangement requirements.

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Switchboards and Switchgear

A switchboard is a large single panel, frame, or assembly of panels with front- or rear-mounted switches, protective devices (overcurrent, etc.), buses, and, usually, instruments. These assemblies are generally accessible from both the front and the rear and are not intended for cabinet installation »*Article 100*«.

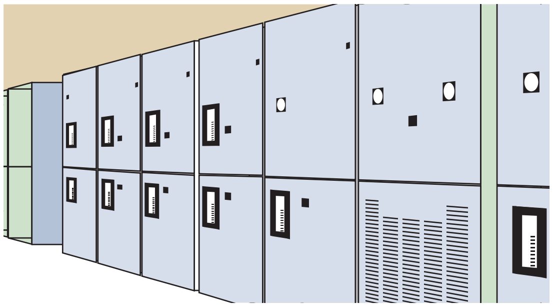
Each switchboard, switchgear, or panelboard used as service equipment shall be provided with a main bonding jumper sized according to 250.28(D) or the equivalent placed within the panelboard or one of the switchboard or switchgear sections for the grounded service conductor connection (on its supply side) to the switchboard, switchgear, or panelboard frame. All switchboard or switchgear sections shall be bonded together using an equipment-bonding jumper or a supply-side bonding jumper sized in accordance with 250.122 or 250.102(C)(1) as applicable »*408.3(C)*«.

Switchboards and switchgear having exposed live parts shall be (1) located in permanently dry locations, (2) under competent supervision, and (3) accessible only to qualified persons. Switchboards and switchgear shall be located to minimize the probability of damage from equipment or processes »*408.20*«.

Anything other than a totally enclosed switchboard or switchgear requires a space not less than 3 ft (900 mm) between the top of the switchboard and switchgear and any combustible ceiling, unless a noncombustible shield separates them »*408.18(A)*«.

Conduit or other raceway entering a switchboard or switchgear, floor-standing panelboard, or similar enclosure from the bottom, requires sufficient space to permit installation of conductors in the enclosure. The wiring space shall meet Table 408.5 specifications where the conduit or raceway enters or leaves the enclosure below the busbars, their supports, or other obstructions. The conduit or raceway, including end fittings, shall not rise more than 3 in. (75 mm) above the bottom of the enclosure »*408.5*«.

Position switchboards and switchgear to reduce the probability of communicating fire to adjacent combustible materials to a minimum. Where installed over a combustible floor, suitable protection shall be provided »*408.17*«.



Note

Switchgear is defined as assembly completely enclosed on all sides and top with sheet metal (except for ventilating openings and inspection windows) and containing primary power circuit switching, interrupting devices, or both, with buses and connections. The assembly may include control and auxiliary devices. Access to the interior of the enclosure is provided by doors, removable covers, or both.

Informational Note: All switchgear subject to *NEC* requirements is metal enclosed. Switchgear rated below 1000 V or less may be identified as "low-voltage power circuit breaker switchgear." Switchgear rated over 1000 V may be identified as "metal-enclosed switchgear" or "metal-clad switchgear." Switchgear is available in non-arc-resistant or arc-resistant constructions »*Article 100*«.

Note

A bushing, or terminal fitting, with an integral bushed opening shall be used at the end of a conduit or other raceway terminating underground where the conductors or cables emerge as a direct burial wiring method. A seal incorporating the same physical protection characteristics can be used in lieu of a bushing »*300.5(H)*«.

Arc-Flash Hazard Warnings

Electrical equipment, such as switchboards, switchgear, enclosed panelboards, industrial control panels, meter socket enclosures, and motor control centers, that is in other than dwelling units, and is likely to require examination, adjustment, servicing, or maintenance while energized, shall be field or factory marked to warn qualified persons of potential electric arc flash hazards. The marking shall meet the requirements in 110.21(B) and shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment »*110.16(A)*«.

Ⓐ An arc-flash hazard warning label meeting the *NEC* requirement in 110.16(A). If the electrical equipment is service equipment rated 1000 amperes or more, the label must be permanent. All arc flash warning labels must comply with 110.21(B) »*110.16(B)*«.

Ⓑ The label shall be permitted to be field or factory applied »*110.16(A)*«.

Ⓒ In other than dwelling units, in addition to the requirements in 110.16(A), a permanent arc flash label shall be field or factory applied to service equipment and feeder-supplied

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Arc-Flash Hazard Warnings *(continued)*

equipment rated 1000 amperes or more. The arc flash label shall be in accordance with applicable industry practice and include the date the label was applied. The label shall meet the requirements of 110.21(B) »*110.16(B)*«.

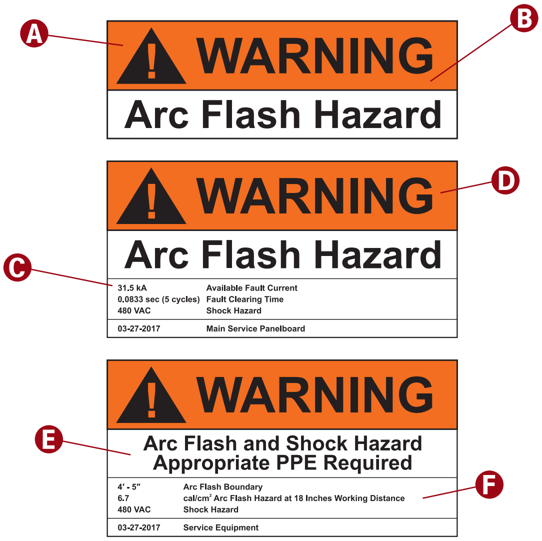
D ANSI Z535.4-2011, Product Safety Signs and Labels, provides guidelines for the design of safety signs and labels for application to products »*110.16 Informational Note No. 1*«.

E An arc-flash hazard warning label meeting the NFPA 70E requirement in 130.5(H).

Note

NFPA 70E-2021, Standard for Electrical Safety in the Workplace, provides guidance, such as determining severity of potential exposure, planning safe work practices, arc flash labeling, and selecting personal protective equipment.

F Acceptable industry practices for equipment labeling are described in NFPA 70E-2021 Standard for Electrical Safety in the Workplace. This standard provides specific criteria for developing arc-flash labels for equipment that provides nominal system voltage, incident energy levels, arc-flash boundaries, minimum required levels of personal protective equipment, and so forth »*110.16(B) Informational Note No. 2*«.


A
B
WARNING
Arc Flash Hazard
D
C
WARNING
Arc Flash Hazard
31.5 kA Available Fault Current
0.0833 sec (5 cycles) Fault Clearing Time
480 VAC Shock Hazard
03-27-2017 Main Service Panelboard
E
WARNING
Arc Flash and Shock Hazard
Appropriate PPE Required
F
4′ - 5″ Arc Flash Boundary
6.7 cal/cm² Arc Flash Hazard at 18 Inches Working Distance
480 VAC Shock Hazard
03-27-2017 Service Equipment

Equipment Markings

Reconditioned equipment shall be marked with the name, trademark, or other descriptive marking by which the organization responsible for reconditioning the electrical equipment can be identified, along with the date of the reconditioning. Reconditioned equipment shall be identified as "reconditioned" and approval of the reconditioned equipment shall not be based solely on the equipment's original listing. The original listing mark must be removed »*110.21(A)(2)*«.

In industrial occupancies, where conditions of maintenance and supervision ensure that only qualified persons service the equipment, the markings indicated in 110.21(A)(2) shall not be required »*110.21(A)(2) Exception*«.

A The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product can be identified shall be placed on all electrical equipment. Other markings that indicate voltage, current, wattage, or other ratings shall be provided as specified elsewhere in this Code. The marking or label shall be of sufficient durability to withstand the environment involved »*110.21(A)(1)*«.

B Where field-applied caution, warning, or danger signs or labels are required by the *NEC*, the labels shall meet the following requirements:

(1) The marking shall warn of the hazards using effective words, colors, symbols, or any combination thereof.

Informational Note No. 2: ANSI Z535.4-2011, Product Safety Signs and Labels, details the design, application, use, and placement of safety signs and labels on a wide variety of products.

(2) The label shall be permanently affixed to the equipment or wiring method and shall not be handwritten.

Exception to (2): Portions of the markings that are variable, or that could be subject to changes, shall be permitted to be handwritten and shall be legible.

(3) The label shall be of sufficient durability to withstand the environment involved »*110.21(B)*«.

C ANSI Z535.4-2011, Environmental and Facility Safety Signs, describes the design, application, and use of safety signs in facilities and the environment »*110.21(B) Informational Note No. 1*«.

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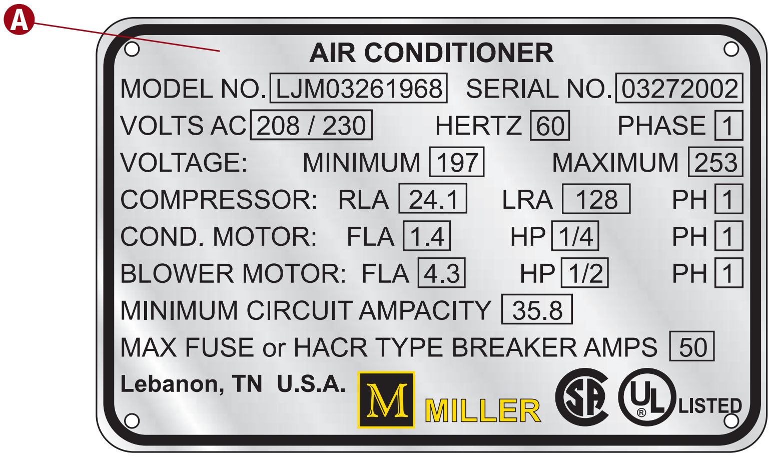
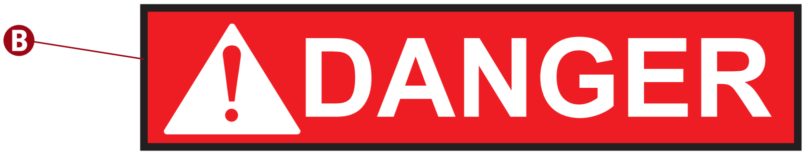


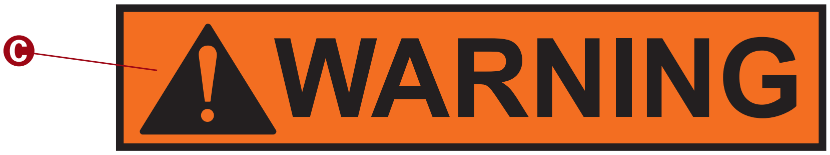
AIR CONDITIONER

MODEL NO. LJM03261968 SERIAL NO. 03272002
VOLTS AC 208 / 230 HERTZ 60 PHASE 1
VOLTAGE: MINIMUM 197 MAXIMUM 253
COMPRESSOR: RLA 24.1 LRA 128 PH 1
COND. MOTOR: FLA 1.4 HP 1/4 PH 1
BLOWER MOTOR: FLA 4.3 HP 1/2 PH 1
MINIMUM CIRCUIT AMPACITY 35.8
MAX FUSE or HACR TYPE BREAKER AMPS 50
Lebanon, TN U.S.A.

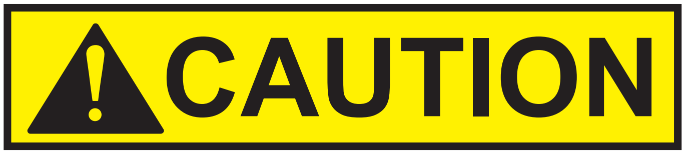
DANGER indicates a hazardous situation and if not avoided, will result in death or serious injury if an accident occurs.



WARNING indicates a hazardous situation and if not avoided, could result in death or serious injury if an accident occurs.



CAUTION indicates a hazardous situation and if not avoided, could result in moderate or minor injury.



Short-Circuit Current Ratings and Fault Current

Ⓐ Service equipment at other than dwelling units shall be legibly marked in the field with the maximum available fault current. The field marking(s) shall include the date the fault current calculation was performed and be of sufficient durability to withstand the environment involved. The calculation shall be documented and made available to those authorized to design, install, inspect, maintain, or operate the system »*110.24(A)*«.

Ⓑ The overcurrent protective devices, the total impedance, the equipment short-circuit current ratings, and other characteristics of the circuit to be protected shall be selected and coordinated to permit the circuit protective devices used to clear a fault to do so without extensive damage to the electrical equipment of the circuit. This fault shall be assumed to be either between two or more of the circuit conductors or between any circuit conductor and the equipment grounding conductor(s) permitted in 250.118. Listed equipment applied in accordance with their listing shall be considered to meet the requirements of this section »*110.10*«.

Ⓒ An arc-flash hazard warning label meeting the *NEC* requirement in 110.16(A).

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Ⓓ Equipment intended to interrupt current at fault levels shall have an interrupting rating at nominal circuit voltage at least equal to the available fault current at the line terminals of the equipment. Equipment intended to interrupt current at other than fault levels shall have an interrupting rating at nominal circuit voltage at least equal to the current that must be interrupted »*110.9*«.

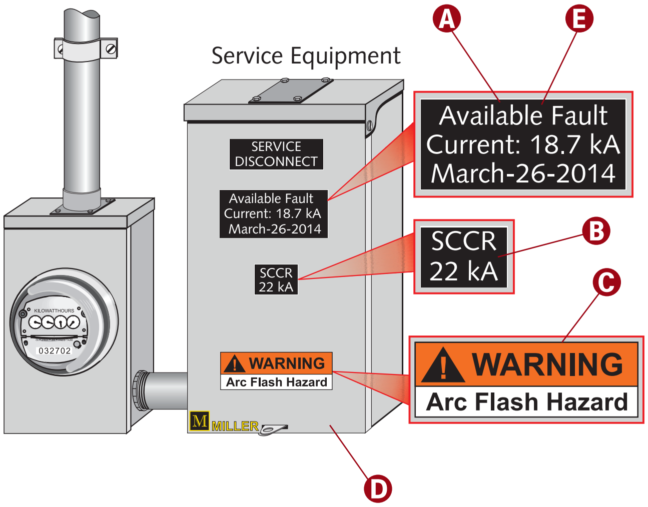
Ⓔ The available fault-current marking(s) addressed in 110.24 is related to the required short-circuit current ratings of equipment. NFPA 70E, 2021, Standard for Electrical Safety in the Workplace, for assistance in determining the severity of potential exposure, planning safe work practices, and selecting personal protective equipment. The available fault current marking(s) addressed in 110.24 is related to required short-circuit current and interrupting ratings of equipment »*110.24(A) Informational Note No. 1*«.

Note

Values of available fault current for use in determining appropriate minimum short-circuit current and interrupting ratings of service equipment are available from electric utilities in published or other forms »***110.24(A) Informational Note No. 2***«.

Caution

When modifications to the electrical installation occur that affect the maximum available fault current at the service, the maximum available fault current shall be verified or recalculated as necessary to ensure the service equipment ratings are sufficient for the available fault current at the line terminals of the equipment. The required field marking(s) in 110.24(A) shall be adjusted to reflect the new level of available fault current »*110.24(B)*«.



Note

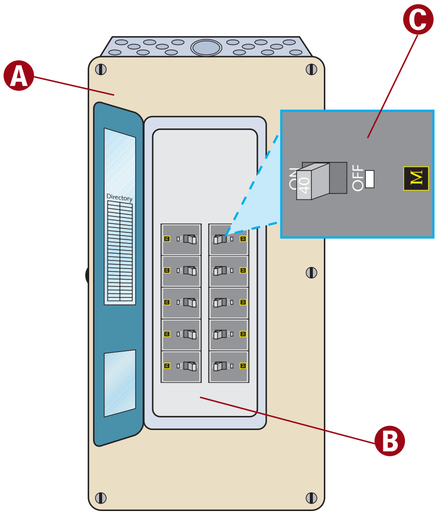
The field marking requirements in 110.24(A) and 110.24(B) shall not be required in industrial installations where conditions of maintenance and supervision ensure that only qualified persons service the equipment »***110.24(A)* and *(B) Exception***«.

Panelboards

Ⓐ *All* panelboards shall have a rating not less than the minimum feeder capacity required for the load calculated in accordance with Part III, IV, or V of Article 220 as applicable »*408.30*«.

Ⓑ In addition to 408.30 requirements, a panelboard shall be protected by an overcurrent protective device with a rating not greater than that of the panelboard. The overcurrent protective device shall be located within or at any point on the supply side of the panelboard »*408.36*«.

Ⓒ A 3-pole circuit breaker or fusible switch shall be considered three overcurrent devices »*408.54*«.



Where a panelboard is supplied through a transformer, the overcurrent protection required by 408.36 shall be located on the secondary side of the transformer »*408.36(B)*«.

A panelboard supplied by the secondary side of a transformer shall be considered as protected by the overcurrent protection provided on the primary side of the transformer where that protection is in accordance with 240.21(C)(1) »*408.36(B) Exception*«.

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Panelboards *(continued)*

Ⓐ Every circuit and circuit modification shall be:

(1) Located at each switch or circuit breaker in a switchboard or switchgear

(2) Included in a circuit directory that is located on the face of, inside of, or in an approved location adjacent to the panel door in the case of a panelboard

(3) Clear, evident, and specific to the purpose or use of each circuit, including spare positions with an unused overcurrent device

(4) Described with a degree of detail and clarity that is unlikely to result in confusion between circuits

(5) Not dependent on transient conditions of occupancy

(6) Clear in explaining abbreviations and symbols when used »*408.4(A)*«.

Ⓑ Panelboards shall be durably marked by the manufacturer with the voltage, the current rating, the number of ac phases or dc buses for which they are designed, and the manufacturer's name or trademark in such a manner so as to be visible after installation, without disturbing the interior parts or wiring »*408.58*«.

Ⓒ Unused openings for circuit breakers and switches shall be closed using identified closures, or other approved means that provide protection substantially equivalent to the wall of the enclosure »*408.7*«.

Ⓓ A 2-pole circuit breaker or fusible switch shall be considered two overcurrent devices »*408.54*«.

Ⓔ Panelboard shall be provided with physical means to prevent the installation of more overcurrent devices than that number for which the panelboard was designed, rated, and listed »*408.54*«.

Note

Individual protection shall not be required for a panelboard protected on its supply side by two main circuit breakers or two sets of fuses in other than service equipment, having a combined rating not greater than that of the panelboard. A panelboard constructed or wired under this exception shall not contain more than 42 overcurrent devices. For the purposes of determining the maximum of 42 overcurrent devices, a 2-pole or a 3-pole circuit breaker shall be considered as two or three overcurrent devices, respectively »*408.36 Exception No. 1*«.

Ⓕ A grounded conductor shall not be connected to normally non-current-carrying metal parts of equipment, to equipment grounding conductor(s), or be reconnected to ground on the load side of the service disconnecting means except as otherwise permitted in Article 250 »*250.24(B)*«.

Ⓖ The enclosure for a panelboard shall have the top and bottom wire-bending space sized in accordance with Table 312.6(B)(2) for the largest conductor entering or leaving the enclosure »*408.55(A)*«.

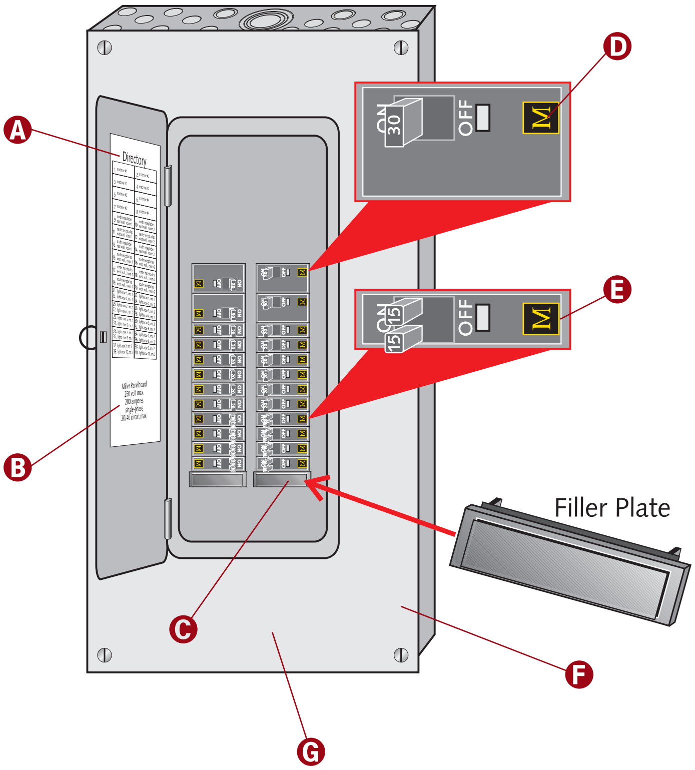
Side wire-bending space shall be in accordance with Table 312.6(A) for the largest conductor to be terminated in that space »*408.55(B)*«.

Caution

Where a raceway or cable entry is in the wall of the enclosure opposite a removable cover, the distance from that wall to the cover shall be permitted to comply with the distance required for one wire per terminal in Table 312.6(A). The distance between the center of the rear entry and the nearest termination for the entering conductors shall not be less than the distance given in Table 312.16(B)(2) »*408.55(C)*«.

Note

Replacement panelboards shall be permitted to be installed in existing enclosures in accordance with 408.9(A) or (B) »*408.9*«.



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Origin of Feeder

Ⓐ All switchboards, switchgear, and panelboards supplied by a feeder(s) in other than one- and two-family dwellings shall be permanently marked in accordance with the following:

(1) With the identification and physical location of where the power originates

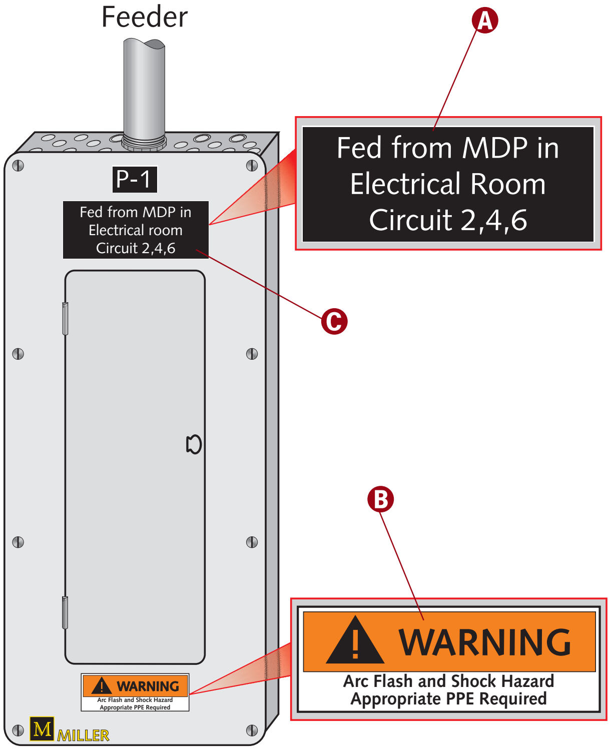
(2) With a label that is permanently affixed and of sufficient durability to withstand the environment involved

(3) Using a method that is not handwritten »*408.4(B)*«.

Ⓑ Electrical equipment, such as switchboards, switchgear, enclosed panelboards, industrial control panels, meter socket enclosures, and motor control centers, that are in other than dwelling units, and are likely to require examination, adjustment, servicing, or maintenance while energized shall be field or factory marked to warn qualified persons of potential electric arc flash hazards. The marking shall meet the requirements in 110.21(B) and shall be located so as to be clearly visible to qualified persons before examination, adjustment, servicing, or maintenance of the equipment »*110.16(A)*«.

NFPA 70E-2021, Standard for Electrical Safety in the Workplace, provides guidance such as determining severity of potential exposure, planning safe work practices, and selecting personal protective equipment »*110.24(A) Informational Note No. 1*«.

Ⓒ The label shall be permanently affixed, of sufficient durability to withstand the environment involved, and not handwritten »*408.4(B)*«.


Feeder
Ⓐ
P-1
Fed from MDP in Electrical room Circuit 2,4,6
Fed from MDP in Electrical Room Circuit 2,4,6
Ⓒ
Ⓑ
WARNING
Arc Flash and Shock Hazard Appropriate PPE Required
WARNING
Arc Flash and Shock Hazard Appropriate PPE Required
MILLER

Grounding—Supply Side of Service

Ⓐ A grounding electrode conductor shall be used to connect the equipment grounding conductors, the service-equipment enclosures, and, where the system is grounded, the grounded service conductor to the grounding electrode(s) required by Part III of Article 250. This conductor shall be sized in accordance with 250.66 »*250.24(E)*«. See 250.64(A) through (G) for grounding electrode conductor installation requirements.

Ⓑ The connection between the grounded circuit conductor (neutral) and the equipment grounding conductor, or the supply-side bonding jumper, or both, at the service is the main bonding jumper »*Article 100*«. For a grounded system, an unspliced main bonding jumper shall be used to connect the equipment grounding conductor(s) and the service-disconnect enclosure to the grounded conductor within the enclosure for each service disconnect in accordance with 250.28 »*250.24(C)*«.

If a main bonding jumper or a system bonding jumper is a screw only, the screw shall be identified with a green finish that shall be visible with the screw installed »*250.28(B)*«.

Ⓒ In accordance with 250.92(A), the normally non-current-carrying metal parts of equipment indicated in (1) and (2) shall be bonded together:

1. All raceways, cable trays, cablebus framework, auxiliary gutters, or service cable armor/sheath that enclose, contain, or support service conductors, except as permitted in 250.80.
2. All enclosures containing service conductors, including meter fittings, boxes, or the like, interposed in the service raceway or armor.

Ⓓ Each service shall have only one disconnecting means unless the requirements of 230.71(B) are met »*230.71*«. Installing two to six service disconnecting means in one panelboard, such as a main lug only panelboard, is not permitted.

Ⓔ A grounded circuit conductor can ground non-current-carrying metal equipment parts, raceways, and other enclosures at any of the following locations listed in 250.142(A):

1. On the supply side, or within the enclosure, of the alternating-current (ac) service disconnecting means.
2. On the supply side, or within the enclosure, of the main disconnecting means for separate buildings as provided in 250.32(B)(1) Exception No. 1.
3. On the supply side, or within the enclosure, of the main disconnecting means or overcurrent devices of a separately derived system where 250.30(A)(1) permits.

Ⓕ The grounded conductor shall not be smaller than specified in Table 250.102(C)(1) »*250.24(D)(1)*«.

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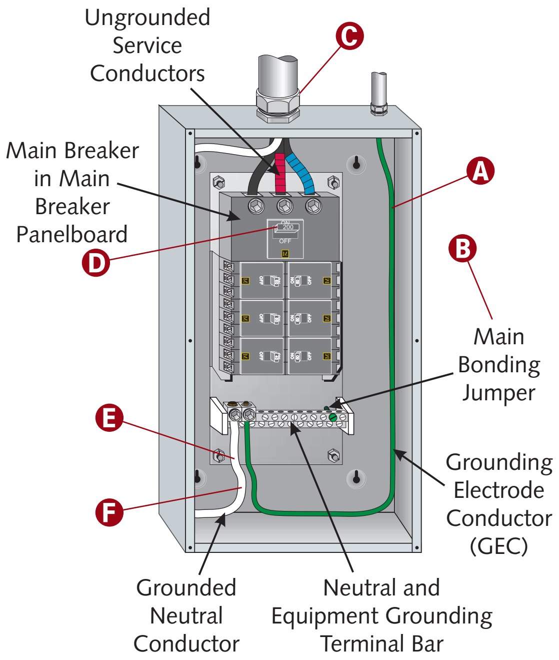
Caution

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following: (1) separate enclosures with a main disconnecting means in each enclosure; (2) panelboards with a main service disconnecting means in each panelboard enclosure; (3) switchboard(s) where there is only one service disconnect in each separate vertical section with barriers separating each vertical section; (4) service disconnects in switchgear, transfer switches, or metering centers where each disconnect is located in a separate compartment; (5) metering centers with a main service disconnecting means in each metering center; or (6) motor control center(s) where there is only one service disconnect in a motor control center and a maximum of two service disconnects provided in a single motor control center with barriers provided between each motor control center unit or compartment containing a service disconnect »*230.71(B)*«.

Warning

Where an ac system operating at 1000 volts or less is grounded at any point, the grounded conductor(s) shall be routed with the ungrounded conductors to each service disconnecting means and shall be connected to each disconnecting means grounded conductor(s) terminal or bus. A main bonding jumper shall connect the grounded conductor(s) to each service disconnecting means enclosure »*250.24(D)*«.


Ungrounded Service Conductors
C
Main Breaker in Main Breaker Panelboard
A
D
B
Main Bonding Jumper
E
Grounding Electrode Conductor (GEC)
F
Grounded Neutral Conductor
Neutral and Equipment Grounding Terminal Bar

Note

Metal water piping system(s) installed in or attached to a building or structure must be bonded to any of the following:
(1) Service equipment enclosure
(2) Grounded conductor at the service
(3) Grounding electrode conductor if of sufficient size
(4) One or more grounding electrodes used, if the grounding electrode conductor or bonding jumper to the grounding electrode is of sufficient size »***250.104(A)(1)***«.

Supply-Side Bonding Jumper

A supply-side bonding jumper is defined as a conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected »*Article 100*«.

Ⓐ The supply-side bonding jumper shall not be smaller than specified in Table 250.102(C)(1) »*250.102(C)(1)*«. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum, the supply-side bonding jumper shall have an area not less than 12½% of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors »*Note 1 under Table 250.102(C)(1)*«. Table 250.102(C)(1) is used for sizing grounded conductors, main bonding jumpers, system bonding jumper, and supply-side bonding jumper for alternating-current systems.

Note

If the circular mill area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum and if the ungrounded supply conductors and the bonding jumper are of different materials (copper, aluminum, or copper-clad aluminum), the minimum size of the grounded conductor or bonding jumper shall be based on the assumed use of ungrounded conductors of the same material as the grounded conductor or bonding jumper that has an ampacity equivalent to that of the installed ungrounded supply conductors »***Note 2. under Table 250.102(C)(1)***«.

Ⓑ Where the ungrounded supply conductors are paralleled in two or more raceways or cables, and an individual supply-side bonding jumper is used for bonding these raceways or cables, the size of the supply-side bonding jumper for each raceway or cable shall be selected from Table 250.102(C)(1), based on the size of the ungrounded supply conductors in each raceway or cable »*250.102(C)(2)*«.

Ⓒ A single supply-side bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with Table 250.102(C)(1) based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable »*250.102(C)(2)(2)*«.

Note

The term supply conductors includes ungrounded conductors that do not have overcurrent protection on their supply side and terminate at service equipment or the first disconnecting means of a separately derived system »***250.102(C)(2) Informational Note No. 1***«.

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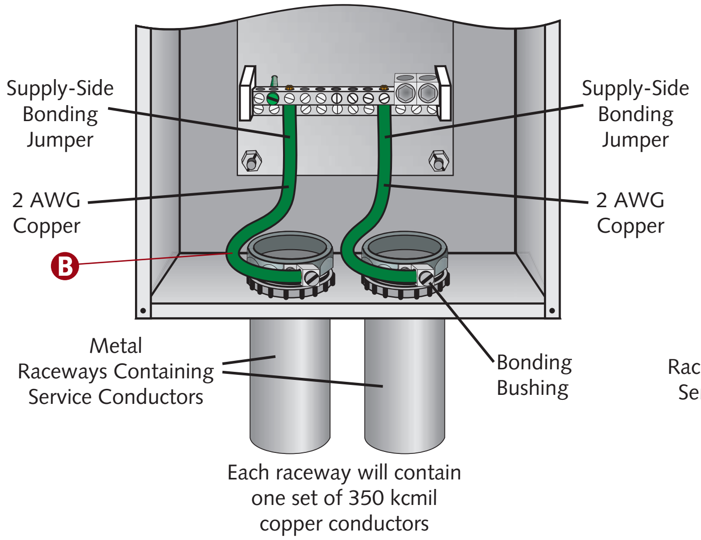
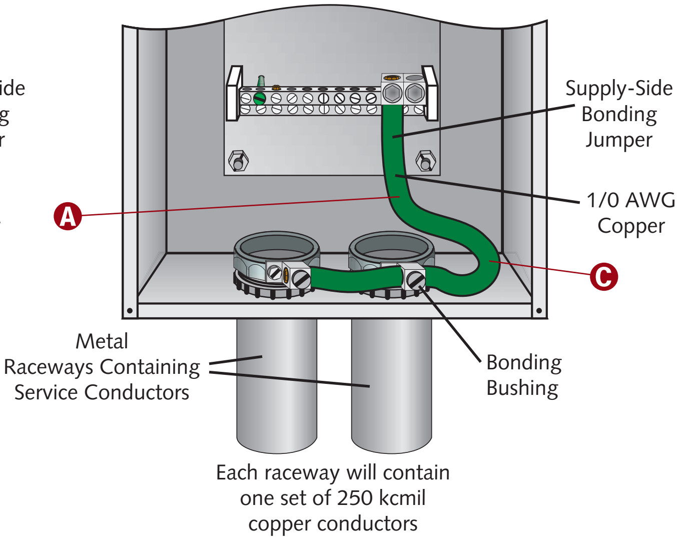
Supply-Side Bonding Jumper *(continued)*

Separate Bonding for Each Raceway


Supply-Side Bonding Jumper
Supply-Side Bonding Jumper
2 AWG Copper
2 AWG Copper
B
Metal Raceways Containing Service Conductors
Bonding Bushing
Each raceway will contain one set of 350 kcmil copper conductors

Common Bonding for Both Raceways


Supply-Side Bonding Jumper
A
1/0 AWG Copper
C
Metal Raceways Containing Service Conductors
Bonding Bushing
Each raceway will contain one set of 250 kcmil copper conductors

Grounding—Load Side of Service

Where ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or 310.15(C), wire-type equipment grounding conductors (where installed) shall be increased in size proportionately, according to the circular mil area of the ungrounded conductors »*250.122(B)*«.

A Equipment bonding jumpers on the load side of an overcurrent device(s) shall be sized in accordance with 250.122. A single common continuous equipment bonding jumper shall be permitted to connect two or more raceways or cables if the bonding jumper is sized in accordance with 250.122 for the largest overcurrent device supplying circuits therein »*250.102(D)*«.

B A grounded conductor shall not be connected to normally non-current-carrying metal parts of equipment, to equipment grounding conductor(s), or be reconnected to ground on the load side of the service disconnecting means except as otherwise permitted in Article 250 »*250.24(B)*«.

C Equipment grounding conductors can be bare, covered, or insulated. Individually covered (or insulated) equipment grounding conductors shall have a continuous outer finish, either green or green with yellow stripe(s), unless otherwise permitted by 250.119 »*250.119(A)*«.

D Metal panelboard cabinets and frames shall physically contact each other and shall be connected to an equipment grounding conductor. If the panelboard is used with nonmetallic raceway (or cable), or if separate equipment grounding conductors are provided, secure a terminal bar for the equipment grounding conductors within the cabinet. The terminal bar shall be bonded to the metal cabinet and panelboard frame. Otherwise, connect it to the equipment grounding conductor that is run with the conductors feeding the panelboard »*408.40*«.

E While equipment grounding conductors of wire type copper, aluminum, or copper-clad aluminum shall not be less than shown in Table 250.122, they are not required to be larger than the circuit conductors supplying the equipment. A raceway, cable armor, or sheath used as the equipment grounding conductor as provided in 250.118 and 250.134(1), must

Note

If conductors are installed in parallel in multiple raceways, wire-type equipment grounding conductors, where used, shall be installed in parallel in each raceway. The equipment grounding conductor installed in each raceway shall be sized in compliance with 250.122 based on the overcurrent protective device for the feeder or branch circuit. Metal raceways or auxiliary gutters in accordance with 250.118 or cable trays complying with 392.60(B) shall be permitted as the equipment grounding conductor **»*250.122(F)(1)(b)* and *(d)*«**.

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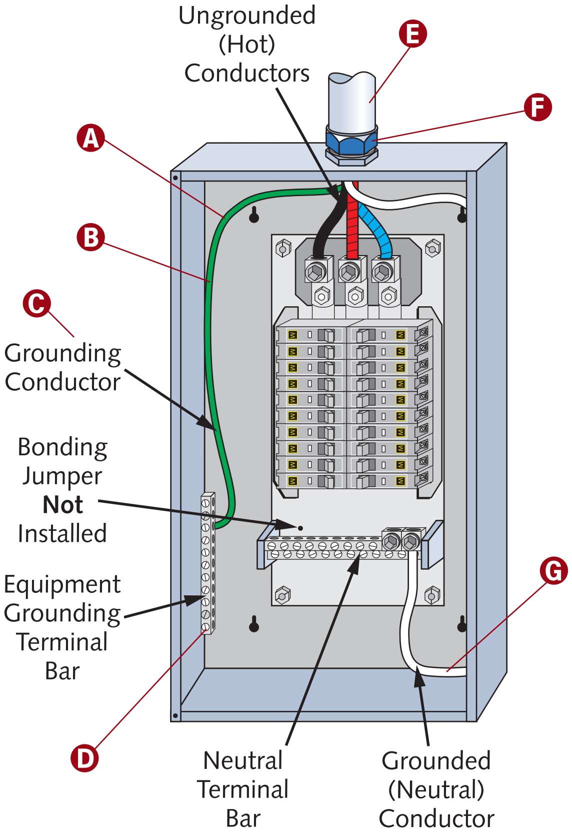
comply with 250.4(A)(5) or 250.4(B)(4). Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with Table 250.122 »*250.122(A)*«.

F Unless grounded by connection to the grounded circuit conductor (permitted by 250.32, 250.140, and 250.142), non-current-carrying metal parts of equipment, raceways, and other enclosures, if grounded, shall be connected to an equipment grounding conductor by one of the following methods: (1) by connection to any of the equipment grounding conductors permitted by 250.118(2) through (14); or (2) by connection to an equipment grounding conductor contained within the same raceway, cable, or otherwise run with the circuit conductors »*250.134*«.

G Except as permitted in 250.30(A)(1), 250.32(B)(1) Exception No. 1, and Part X of Article 250, a grounded circuit conductor shall not be used for grounding non-current-carrying metal equipment parts on the load side of the service disconnecting means, on the load side of a separately derived system disconnecting means, or the overcurrent device for a separately derived system not having a main disconnecting means, unless an exception has been met »*250.142(B)*«.


Ungrounded (Hot) Conductors
E
F
A
B
C
Grounding Conductor
Bonding Jumper **Not** Installed
Equipment Grounding Terminal Bar
G
D
Neutral Terminal Bar
Grounded (Neutral) Conductor

Ground-Fault Protection of Equipment

If a switch and fuse combination is used, the fuses employed shall be capable of interrupting any current higher than the interrupting capacity of the switch when the ground-fault protective system will not cause the switch to open »*230.95(B)*«.

Ground-fault protection that functions to open the service disconnect will afford no protection from faults on the line side of the protective element. It serves to limit damage to conductors and equipment only on the load side of the protective element in the event of an arcing ground fault »*230.95(C) Informational Note No. 1*«.

This added protective apparatus at the service equipment could necessitate a review of the overall wiring system for proper selective overcurrent protection coordination. Additional installations of ground-fault protective equipment might be needed on feeders and branch circuits requiring maximum continuity of electrical service »*230.95(C) Informational Note No. 2*«.

Where ground-fault protection is provided for the service disconnect and another supply system is interconnected by a transfer device, a method could be needed to ensure proper sensing by the ground-fault protection equipment »*230.95(C) Informational Note No. 3*«.

A Ground-fault protection of equipment shall be provided for solidly grounded wye electrical services of more than 150 volts to ground but not exceeding 1000 volts phase-to-phase for each service disconnect rated 1000 amperes or more. The grounded conductor for the solidly grounded wye system shall be connected directly to ground through a grounding electrode system, as specified in 250.50, without inserting any resistor or impedance device »*230.95* and *240.13*«.

B The service disconnect rating is considered to be the rating of the largest fuse that can be installed or the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated (or can be adjusted) »*230.95*«.

C Ground-fault protection systems, when activated, shall cause the service disconnect to open all ungrounded conductors of the faulted circuit. The maximum ground-fault setting is 1200 amperes »*230.95(A)*«.

D One second is the maximum time delay for ground-fault currents of 3000 amperes or more »*230.95(A)*«.

E **Ground-Fault Protection of Equipment** is a system intended to provide protection of equipment from damaging line-to-ground fault currents by causing the disconnecting means to open all ungrounded conductors of the faulted circuit. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device »*Article 100*«.

Note

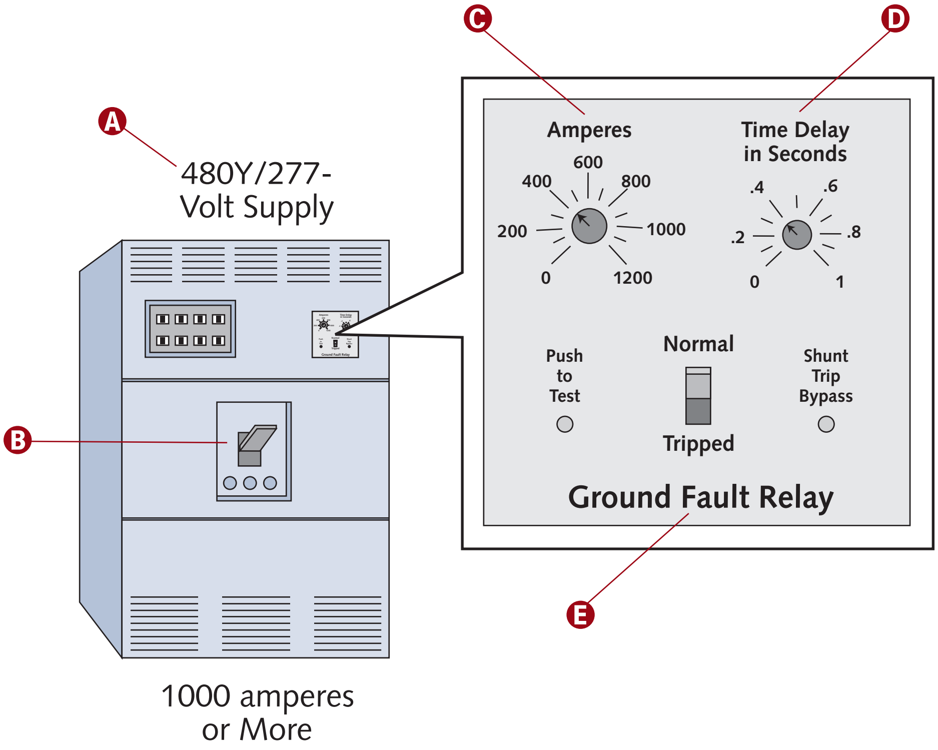
Section 230.95 ground-fault protection of equipment shall not be installed in any fire pump power circuit »***240.13(3)* and *695.6(G)***«. The ground-fault protection provisions of 230.95 do not apply to a service disconnect for a continuous industrial process where a nonorderly shutdown introduces additional or increased hazards »***230.95 Exception* and *240.13(1)***«.

Caution

Bonding for circuits over 250 volts to ground must comply with 250.97.

Note

See 215.10 for ground-fault protection of equipment for feeders and 210.13 for ground-fault protection of equipment for branch circuits.



Separately Derived Systems

Transformers

Article 450 covers the installation of all transformers except:

1. **Current transformers.**
2. **Dry-type transformers that constitute a component of other apparatus and comply with these requirements.**
3. **Transformers that are an integral part of X-ray, high-frequency, or electrostatic-coating apparatus.**
4. **Transformers used with Class 2 and Class 3 circuits.**
5. **Sign and outline lighting transformers.**
6. **Transformers for electric-discharge lighting.**

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7. **Power-limited fire alarm circuit transformers.**
8. **Transformers used for research, development, or testing, where effective safeguards protect persons from contacting energized parts »*450.1*«.**

Article 450 covers the installation of transformers dedicated to supplying power to a fire pump installation as modified by Article 695.

Article 450 covers the installation of transformers in hazardous (classified) locations as modified by Articles 501 through 504.

Autotransformers are covered in 450.4 and 450.5.

Appropriate provisions shall be made to minimize the possibility of damage to transformers from external causes where the transformers are exposed to physical dangers »*450.8(A)*«.

Ⓐ A transformer is defined as equipment, either single-phase or polyphase, that uses electromagnetic induction to convert current and voltage in a primary circuit into current and voltage in a secondary circuit »*Article 100*«.

Ⓑ Overcurrent protection for transformers over 1000 volts, nominal, shall be provided in accordance with Table 450.3(A) »*450.3(A)*«.

Ⓒ Each transformer shall have a nameplate giving the manufacturer's name; rated kilovolt-amperes; frequency; primary and secondary voltage; impedance of transformers (25 kVA and larger); required clearances for transformers with ventilating openings; and the amount and kind of insulating liquid (where used). In addition, the nameplate of each dry-type transformer shall include the insulation system's temperature class »*450.11(A)*«.

Ⓓ Transformers with ventilation openings shall be installed so that such openings are not blocked by walls or other obstructions. The required clearances shall be legibly marked on the transformer »*450.9*«.

Ⓔ Dry-type transformers rated 1000 volts, nominal, or less and not exceeding 50 kVA are permitted in hollow spaces of buildings that are not permanently closed in, provided they meet 450.9 ventilation requirements and 450.21(A) separation from combustible material requirements. Transformers so installed do not have to be readily accessible »*450.13(B)*«.

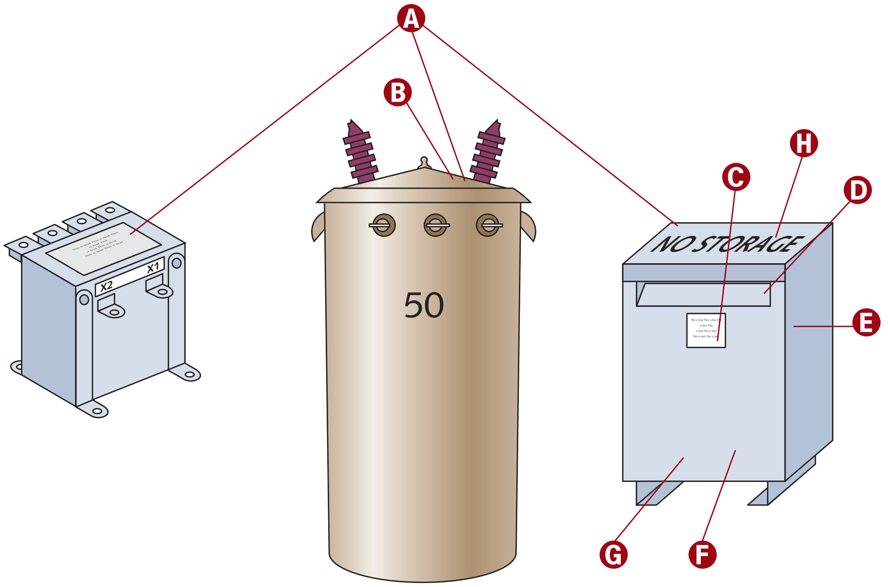
Ⓕ It is not required that dry-type transformers rated 1000 volts, nominal, or less located in the open on walls, columns, or structures be readily accessible »*450.13(A)*«.

Ⓖ Exposed non-current-carrying metal parts of transformer installations (fences, guards, and so on), shall be grounded and bonded, under the conditions and in a manner specified for electric equipment and other exposed metal parts in Parts V, VI, and VII of Article 250 »*450.10(B)*«.

Ⓗ Transformer top surfaces that are horizontal and readily accessible shall be marked to prohibit storage »*450.9*«.

Note

All transformers and their vaults shall be readily accessible to qualified personnel for inspection and maintenance, or shall otherwise meet 450.13(A) or (B) requirements »***450.13***«.



Transformer Disconnecting Means

Transformers, other than Class 2 or Class 3 transformers, shall have a disconnecting means located either in sight of the transformer or in a remote location. Where located in a remote location, the disconnecting means shall be lockable in accordance with 110.25, and its location shall be field marked on the transformer »*450.14*«.

Ⓐ Since the transformer's disconnecting means is within sight of the transformer, it is not required to field mark the location on the transformer.

Ⓑ Each disconnecting means shall be legibly marked to indicate its purpose unless located and arranged so the

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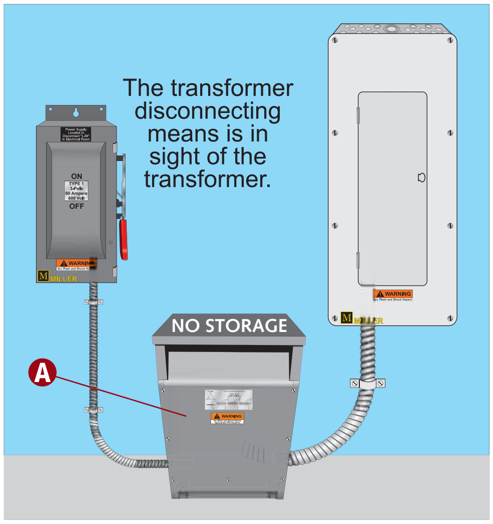
Transformer Disconnecting Means *(continued)*

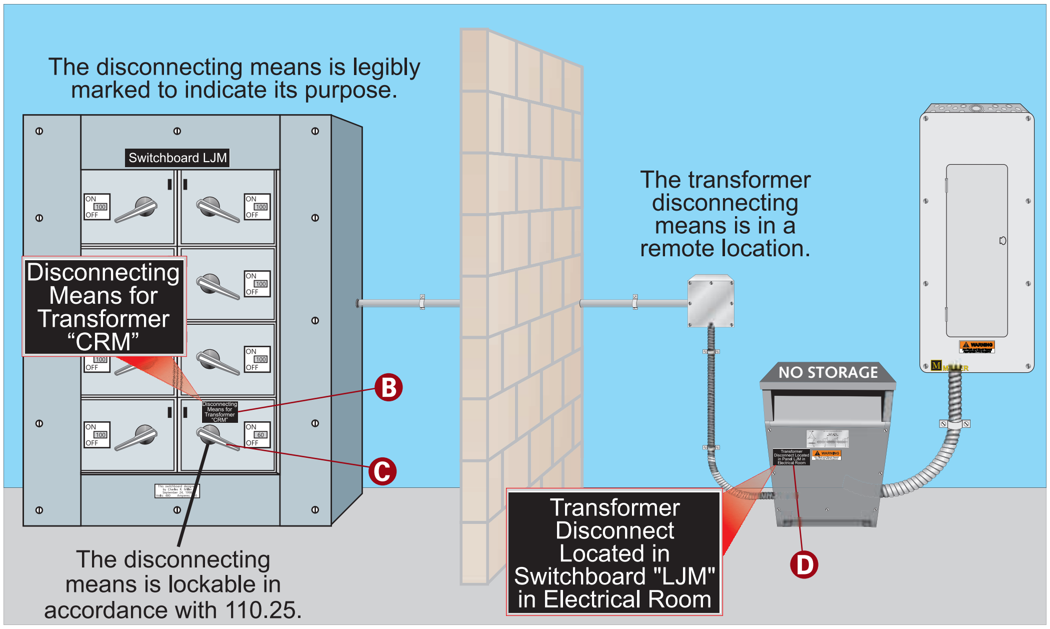
purpose is evident. The marking shall be of sufficient durability to withstand the environment involved »*110.22(A)*«.

Ⓒ If a disconnecting means is required to be lockable open elsewhere in this Code, it shall be capable of being locked in the open position. The provisions for locking shall remain in place with or without the lock installed »*110.25*«.

Ⓓ This transformer must be field marked to show the location of the disconnecting means because the disconnecting means is not within sight of the transformer.



The transformer disconnecting means is in sight of the transformer.
ON
OFF
NO STORAGE
A



The disconnecting means is legibly marked to indicate its purpose.
Switchboard LJM
Disconnecting Means for Transformer "CRM"
B
C
The transformer disconnecting means is in a remote location.
NO STORAGE
Transformer Disconnect Located in Switchboard "LJM" in Electrical Room
D
The disconnecting means is lockable in accordance with 110.25.

Transformer—Primary-Only Protection 9 Amperes or More—1000 Volts or Less

Conductors supplied by the secondary side of a single-phase transformer having a 2-wire (single-voltage) secondary, or a 3-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary, can be protected by overcurrent protection situated on the primary (supply) side of the transformer, provided this protection is in accordance with 450.3 and does not exceed the value determined when multiplying the secondary conductor ampacity by the secondary to primary transformer voltage ratio »*240.21(C)(1)*«.

Ⓐ Where 125% of this current does not correspond to a standard fuse or nonadjustable circuit-breaker rating, the next higher rating (described in 240.6) is permitted »*Table 450.3(B) Note 1*«.

Ⓑ This represents either a single-phase transformer having a 2-wire (single-voltage) secondary, or a 3-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary.

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Ⓒ No secondary overcurrent protection is required for certain transformers 1000 volts, nominal, or less with currents of at least 9 amperes and a maximum primary overcurrent protection of 125% »*Table 450.3(B)*«. (The absence of secondary protection applies only to certain panelboards. See 408.36(B) Exception.)

Ⓓ Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors are not considered protected by the primary overcurrent protective device »*240.21(C)(1)*«.

Ⓔ Overcurrent protection for transformers rated 1000 volts, nominal, or less must be provided in accordance with Table 450.3(B), unless the transformer is installed as a motor-control circuit transformer in accordance with 430.72(C)(1) through (5) »*450.3(B)*«.

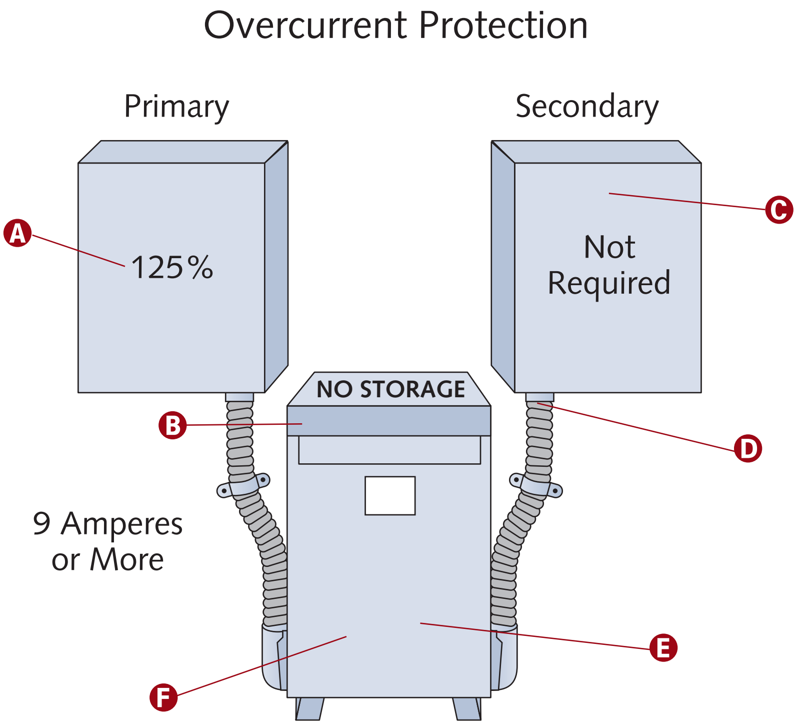
Ⓕ This transformer is a 3-phase, delta-delta connected transformer having a 3-wire (single-voltage) secondary. Therefore, secondary overcurrent protection is not required.

Warning

Although Table 450.3(B) does not require secondary overcurrent protection for all transformers, 408.36(B) requires secondary overcurrent for most panelboards. Where a panelboard is supplied through a transformer, locate the overcurrent protection on the transformer's secondary side »*408.36(B)*«. A panelboard supplied by the secondary side of a transformer is considered as protected by the overcurrent protection provided on the transformer's primary side, where that protection complies with 240.21(C)(1) »*408.36(B) Exception*«.

Caution

Article 450 covers requirements for transformers, not for transformer conductors. Other than single-phase, 2-wire (with a single-voltage secondary) and delta-delta, 3-wire (with a single-voltage secondary) transformers, transformer secondary conductors shall be protected by an overcurrent protective device such as a circuit breaker or fuse [see 240.4(F) and 240.21(C)(1)].



Transformer—Primary and Secondary Protection 9 Amperes or More—1000 Volts or Less

Ⓐ Unlike Note 1 that permits the next standard rating above 125%, the **maximum** rating or setting is 250%.

Ⓑ A transformer equipped with coordinated thermal overload protection (by the manufacturer) and arranged to interrupt the primary current can have primary overcurrent protection rated (or set) at a current value not more than six times the rated current of transformers having not more than 6% impedance and not more than four times the rated

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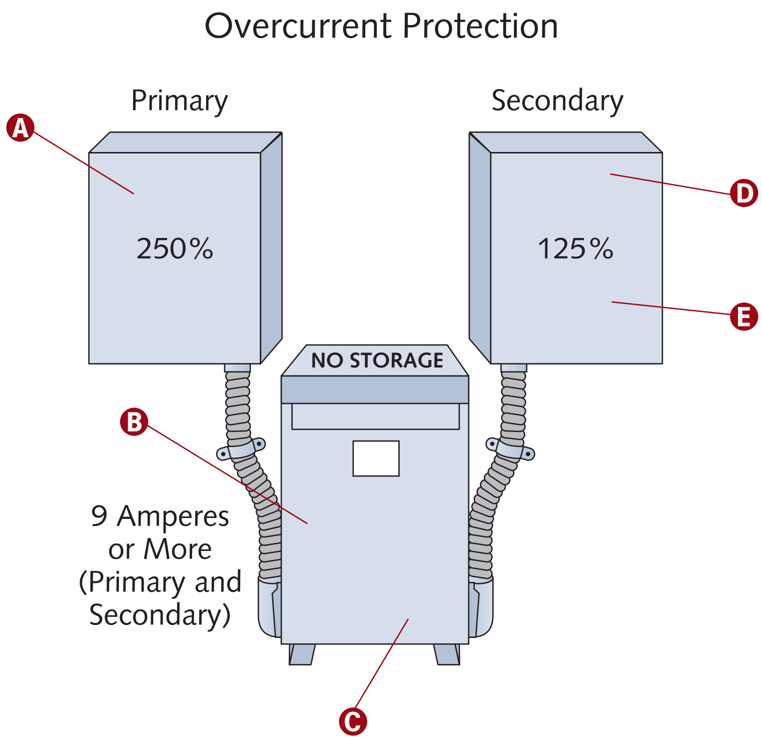
Transformer—Primary and Secondary Protection 9 Amperes or More—1000 Volts or Less *(continued)*

current of transformers having more than 6%, but not more than 10%, impedance »*Table 450.3(B) Note 3*«.

C Overcurrent protection for transformers rated 1000 volts, nominal, or less must be provided according to Table 450.3(B), unless the transformer is installed as a motor-control circuit transformer per 430.72(C)(1) through (5) »*450.3(B)*«.

D Where 125% of this current does not correspond to a standard fuse or nonadjustable circuit breaker rating, the next higher rating described in 240.6 is permitted »*Table 450.3(B) Note 1*«.

E If secondary overcurrent protection is required, these devices are permitted to consist of no more than six circuit breakers (or six sets of fuses) grouped in one location. Where multiple overcurrent devices are implemented, the total of all the device ratings must not exceed the single overcurrent device allowed value »*Table 450.3(B) Note 2*«.



Grounding and Bonding—Terminating in the Panel

Premises wiring (system) is defined as interior and exterior wiring, including power, lighting, control, and signal circuit wiring together with all their associated hardware, fittings, and wiring devices, both permanently and temporarily installed. This includes (1) wiring from the service point or power source to the outlets or (2) wiring from and including the power source to the outlets where there is no service point. Such wiring does not include wiring internal to appliances, luminaires, motors, controllers, motor control centers, and similar equipment »*Article 100*«.

A grounded circuit conductor can be used to ground non-current-carrying metal parts of equipment, raceways, and other enclosures on the supply side or within the enclosure of the main disconnecting means (or overcurrent devices) of a separately derived system as permitted by 250.30(A)(1) »*250.142(A)(3)*«.

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Grounding and Bonding—Terminating in the Panel *(continued)*

Ⓐ An unspliced system bonding jumper shall comply with 250.28(A) through (D). This connection shall be made at any single point on the separately derived system from the source to the first system disconnecting means (or overcurrent devices) or shall be made at the source of a separately derived system that has no disconnecting means or overcurrent devices, in accordance with 250.30(A)(1)(a) or (b). The system bonding jumper shall remain within the enclosure where it originates. If the source is located outside the building or structure supplied, a system bonding jumper shall be installed at the grounding electrode connection in compliance with 250.30(C) »*250.30(A)(1)*«.

Ⓑ A grounding electrode conductor for a single separately derived system shall be sized in accordance with 250.66 for the derived ungrounded conductors. It shall be used to connect the grounded conductor of the derived system to the grounding electrode in accordance with 250.30(A)(4), or as permitted in 250.68(C)(1) and (2). This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected unless one of the exceptions is met »*250.30(A)(5)*«.

Ⓒ For vertically operated circuit-breaker handles, the "up" position of the handle shall be the "on" position »*240.81*«.

Ⓓ A grounded separately derived ac system shall comply with 250.30(A)(1) through (8), unless it is an impedance grounded neutral system installed as specified in 250.36 or 250.187, as applicable »*250.30(A)*«.

Ⓔ Size the equipment grounding conductor in accordance with 250.122. The equipment grounding conductor must be of the types listed in 250.118(A).

Ⓕ If a building or structure is supplied by a feeder from an outdoor separately derived system, a system bonding jumper at both the source and the first disconnecting means is permitted, if doing so does not establish a parallel path for the grounded conductor. While grounded conductors used in this manner shall not be smaller than the size specified for the system bonding jumper, they do not have to be larger than the ungrounded conductor(s). In applying this exception, connection through the earth does not qualify as providing a parallel path »*250.30(A)(1) Exception No. 2*«.

Ⓖ Grounding (and bonding) terminations made at the system disconnecting means or overcurrent device require that the transformer's grounded (neutral) bus be insulated from the transformer enclosure. If the neutral bus is bonded to the enclosure and the raceway to the panelboard is metallic, then part of the neutral current flows on the raceway. Section 250.6(A) prohibits objectionable current flow over grounding paths or grounding conductors.

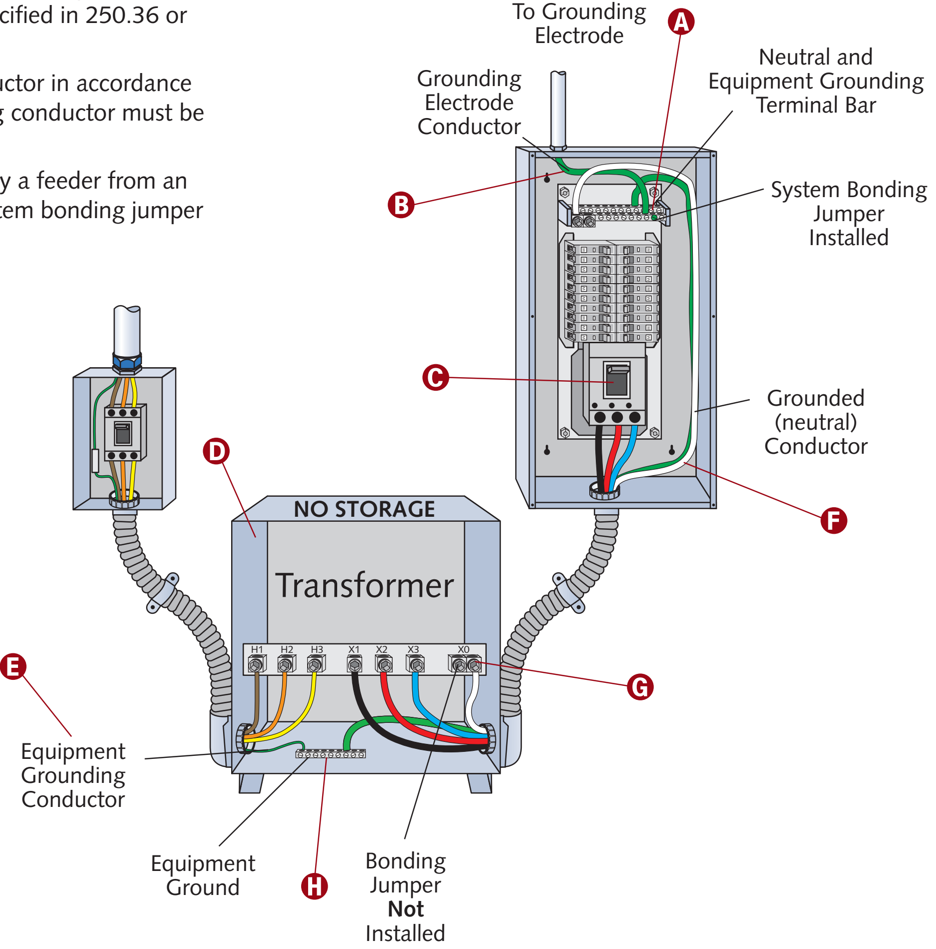
Ⓗ Where separate equipment grounding conductors and supply-side bonding jumpers are installed, a terminal bar for all grounding and bonding conductor connections shall be secured inside the transformer enclosure. The terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any vented portion of the enclosure »*450.10(A)*«.

Note

Transformers, which are only one type of separately derived system, are used to illustrate and explain 250.30.

Caution

Except as otherwise permitted in Article 250, a grounded conductor shall not be connected to normally non-current-carrying metal parts of equipment, be connected to equipment grounding conductors, or be reconnected to ground on the load side of the system bonding jumper »*250.30(A)*«.


To Grounding Electrode
A
Neutral and Equipment Grounding Terminal Bar
Grounding Electrode Conductor
B
System Bonding Jumper Installed
C
Grounded (neutral) Conductor
D
F
NO STORAGE
Transformer
H1
H2
H3
X1
X2
X3
X0
E
G
Equipment Grounding Conductor
Equipment Ground
H
Bonding Jumper **Not** Installed

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Grounding and Bonding—Terminating in the Transformer

While a 3-phase separately derived system is used for this illustration, the same rules apply to single-phase systems.

A system supplying power to a Class 1, Class 2, or Class 3 circuit having the power derived from a transformer rated 1000 volt-amperes or less must have a system bonding jumper sized no smaller than the derived ungrounded conductors. The smallest size allowed is 14 AWG copper or 12 AWG aluminum »*250.30(A)(1) Exception No. 3*«.

A system that supplies a Class 1, 2, or 3 circuit and is derived from a transformer rated no more than 1000 volt-amperes does not require a grounding electrode conductor, provided the grounded conductor is bonded to the transformer frame (or enclosure) by means of a jumper sized in accordance with 250.30(A)(1), Exception No. 3, and the transformer frame (or enclosure) is grounded by one of the means specified in 250.134 »*250.30(A)(5) Exception No. 3*«.

A If the grounding (and bonding) terminations are made at the transformer, the system disconnecting means (or overcurrent device) grounded (neutral) terminal bar must be insulated from both the panelboard enclosure and the equipment grounding conductor. If the neutral terminal bar is bonded to the enclosure as well as the equipment grounding conductor, part of the neutral current will flow through the raceway (if metallic) and the equipment grounding conductor. Section 250.6(A) strictly prohibits such a condition.

B Except as permitted in 250.30(A)(1), 250.32(B)(1) Exception No. 1, and Part X of Article 250, a grounded circuit conductor shall not be used for grounding non-current-carrying metal equipment parts on the load side of a separately derived system disconnecting means (or the overcurrent devices) for a separately derived system having no main disconnecting means »*250.142(B)*«.

C The system bonding jumper connection can be made at any point on the separately derived system from the source to the first disconnecting means or overcurrent device, that is, in either the panel or transformer »*250.30(A)(1)*«.

D A grounding electrode conductor for a single separately derived system shall be sized in accordance with 250.66 for the derived ungrounded conductors. It shall be used to connect the grounded conductor of the derived system to the grounding electrode in accordance with 250.30(A)(4), or as permitted in 250.68(C)(1) and (2). This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected »*250.30(A)(5)*«.

E Use an unspliced system bonding jumper that complies with 250.28(A) through (D) to connect the equipment grounding conductors of the separately derived system to the grounded conductor »*250.30(A)(1)*«.

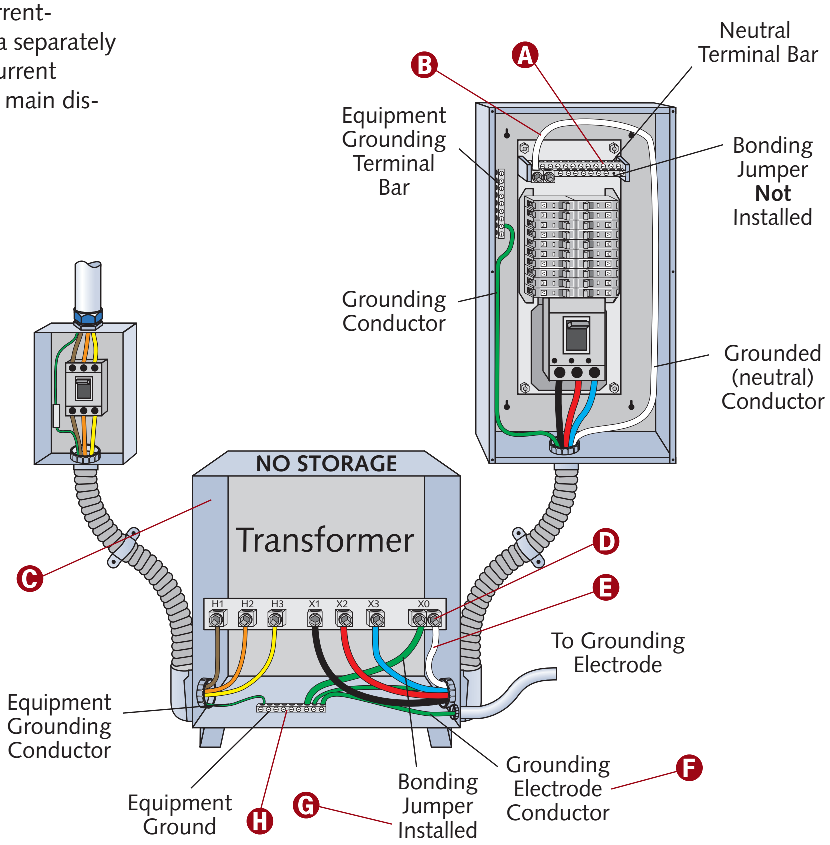
F The grounding electrode conductor installation must comply with 250.64(A), (B), (C), and (E) »*250.30(A)(7)*«.

Grounding electrode conductors shall not be installed through a ventilation opening of an enclosure »*250.64(G)*«

G If the system bonding jumper specified in 250.30(A)(1) is a wire or busbar, it shall be permitted to connect the grounding electrode conductor to the equipment grounding terminal, bar, or bus if the equipment grounding terminal, bar, or bus is of sufficient size for the separately derived system »*250.30(A)(5) Exception No. 1*«.

H Where separate equipment grounding conductors and supply-side bonding jumpers are installed, a terminal bar for all grounding and bonding conductor connections shall be secured inside the transformer enclosure. The terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any vented portion of the enclosure »*450.10(A)*«.

Where a dry-type transformer is equipped with wire-type connections (leads), the grounding and bonding connections shall be permitted to be connected together using any of the methods in 250.8 and shall be bonded to the enclosure if of metal »*450.10(A) Exception*«.


B
A
Neutral Terminal Bar
Equipment Grounding Terminal Bar
Bonding Jumper **Not** Installed
Grounding Conductor
Grounded (neutral) Conductor
NO STORAGE
Transformer
H1
H2
H3
X1
X2
X3
X0
C
D
E
To Grounding Electrode
Equipment Grounding Conductor
Equipment Ground
H
G
Bonding Jumper Installed
Grounding Electrode Conductor
F

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Grounding Electrode and Grounding Electrode Conductor

Metal water piping systems and structural metal that is interconnected to form a building frame shall be bonded to separately derived systems in accordance with 250.104(D)(1) through 250.104(D)(3) »*250.104(D)*«. Metal water piping systems are covered in 250.104(D)(1), structural metal is covered in 250.104(D)(2), and common grounding electrode conductors are covered in 250.104(D)(3).

A The building or structure grounding electrode system shall be used as the grounding electrode for the separately derived system. If located outdoors, the grounding electrode shall be in accordance with 250.30(C) »*250.30(A)(4)*«.

If a separately derived system originates in equipment that is listed and identified as suitable for use as service equipment, the grounding electrode used for the service or feeder equipment shall be permitted to be used as the grounding electrode for the separately derived system »*250.30(A)(4) Exception*«.

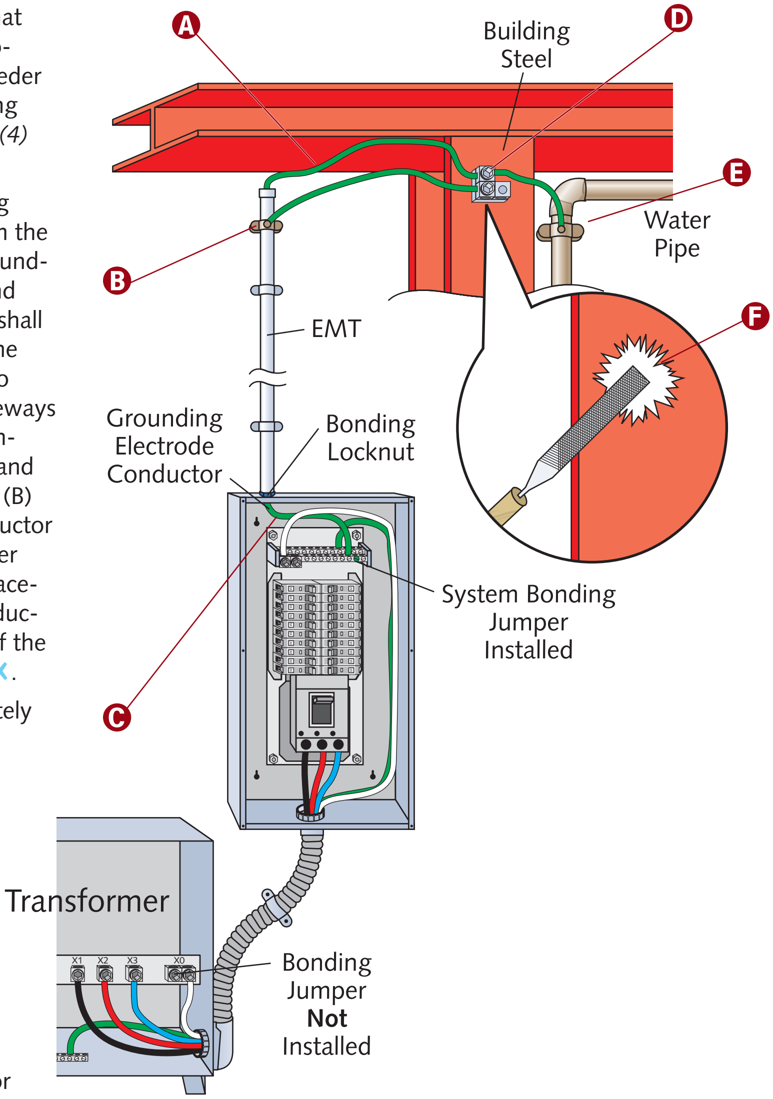
B Ferrous metal raceways and enclosures for grounding electrode conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode and shall be securely fastened to the ground clamp or fitting. Ferrous metal raceways and enclosures shall be bonded at each end of the raceway or enclosure to the grounding electrode or grounding electrode conductor to create an electrically parallel path. Nonferrous metal raceways and enclosures shall not be required to be electrically continuous. Bonding shall be in compliance with 250.92(B) and ensured by one of the methods in 250.92(B)(2) through (B)(4). The bonding jumper for a grounding electrode conductor raceway or cable armor shall be the same size as, or larger than, the enclosed grounding electrode conductor. If a raceway is used as protection for a grounding electrode conductor, the installation shall comply with the requirements of the appropriate raceway article »*250.64(E)(1) through (4)*«.

C A grounding electrode conductor for a single separately derived system shall be sized according to 250.66 for the derived ungrounded conductors. It shall be used to connect the grounded conductor of the derived system to the grounding electrode in accordance with 250.30(A)(4), or as permitted in 250.68(C)(1) and (2). This connection shall be made at the same point on the separately derived system where the system bonding jumper is connected »*250.30(A)(5)*«.

D All mechanical elements used to terminate a grounding electrode conductor or bonding jumper to a grounding electrode shall be accessible »*250.68(A)*«.

E Each separately derived system's grounded conductor shall be bonded to the nearest accessible point of interior metal water piping system(s) in the area served by each separately derived system. This connection shall be made at the same point on the separately derived system as the grounding electrode conductor connection. Size the bonding jumper per Table 250.102(C)(1) based on the largest ungrounded conductor of the separately derived system except that it shall not be required to be larger than 3/0 AWG copper or 250 kcmil aluminum »*250.104(D)(1)*«.

F Equipment requiring grounding and having a nonconductive coating (such as paint, lacquer, and enamel) shall have the coating removed from threads and other contact surfaces to ensure good electrical continuity (unless connected by fittings that are designed so as to make the removal unnecessary) »*250.12*«.


A
Building Steel
D
E
Water Pipe
B
EMT
F
Grounding Electrode Conductor
Bonding Locknut
System Bonding Jumper Installed
C
Transformer
X1
X2
X3
X0
Bonding Jumper **Not** Installed

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Generators

Article 445 contains installation and other requirements for generators »*445.1*«.

Live generator parts operating at more than 50 volts ac or 60 volts dc to ground shall not be exposed to accidental contact by unqualified persons »*445.14*«.

While legally required standby system requirements for generators and associated equipment are located in Article 701, optional standby system provisions are found in Article 702.

Ⓐ The conductor ampacity from the generator output terminals to the first distribution device(s) containing overcurrent device shall not be less than 115% of the generator's nameplate current rating »*445.13(A)*«.

Ⓑ An alternate ac power source, such as an on-site generator, is not a separately derived system if the grounded conductor is solidly interconnected to a service-supplied system grounded conductor. An example of such a situation is where alternate source transfer equipment does not include a switching action in the grounded conductor and allows it to remain solidly connected to the service-supplied grounded conductor when the alternate source is operational and supplying the load served »*250.30 Informational Note No. 1*«.

Ⓒ Generator provisions are also covered in Articles 695, 700, 701, 702, and 705.

Ⓓ The type of generator used shall be suitable for the installed location. The motor requirements in 430.14 shall also be met »*445.10*«.

Ⓔ Depending on the generator type, overcurrent protection must meet 445.12 specifications.

Ⓕ Generators other than cord-and-plug-connected portable shall have one or more disconnecting means. Each disconnecting means shall simultaneously open all associated ungrounded conductors. Each disconnecting means shall be lockable in the open position in accordance with 110.25 »*445.18(A)*«.

Ⓖ Where field-installed wiring passes through an opening in an enclosure, a conduit box, or a barrier, a bushing shall protect the conductors from any sharp edges. The bushing surfaces shall be smooth and well-rounded where they may contact the conductors. If oils, grease, or other contaminants are present, the bushing shall be made of a material not harmfully affected »*445.16*«.

Ⓗ Each generator shall have an accessible nameplate identifying the manufacturer; the rated frequency; the number of phases if ac; the rating in kilowatts or kilovolt amperes; the power factor; the normal volts and amperes corresponding to the rating; and the rated ambient temperature.

Nameplates or manufacturer's instructions shall provide the information required in 445.11 for all stationary generators and portable generators rated more than 15 kW.

Marking shall be provided by the manufacturer to indicate whether or not the generator neutral is bonded to its frame. Where the bonding is modified in the field, additional marking shall be required to indicate whether the neutral is bonded to the frame »*445.11*«.

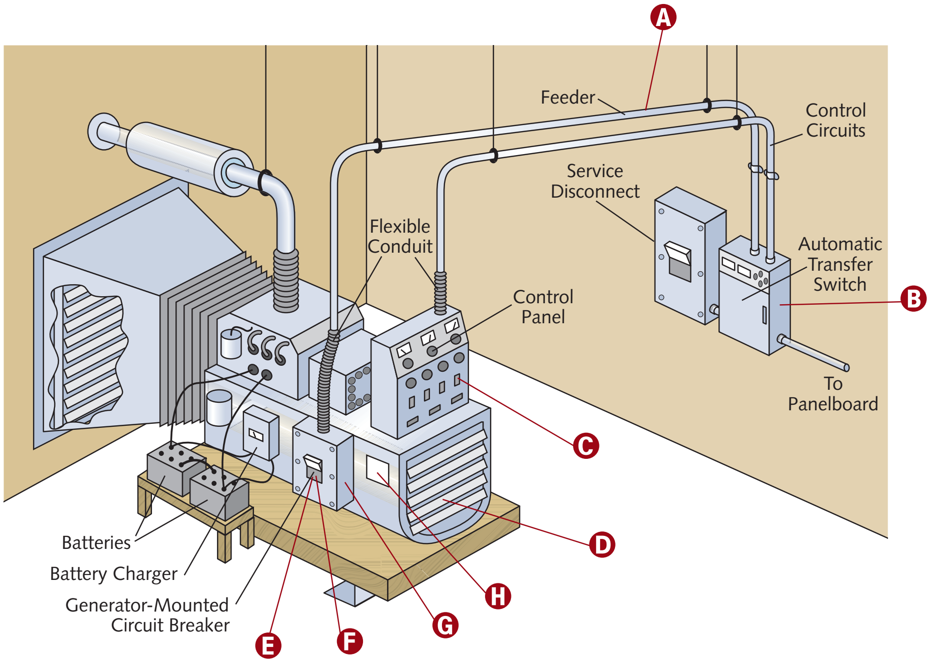
Note

Portable vehicle- and trailer-mounted generators must be grounded in accordance with 250.34.

A generator meeting the qualifications of a separately derived system must be grounded per 250.30 specifications.

Note

Receptacle outlets that are a part of a 15-kW or smaller portable generator shall have listed ground-fault circuit-interrupter protection (GFCI) for personnel integral to the generator or receptacle as indicated in either 445.20(A) or (B). Section 445.20(A) pertains to unbonded (floating neutral) generators and 445.20(B) pertains to bonded neutral generators »***445.20***«.



Note

Where the generator set is equipped with a listed overcurrent protective device or a combination of a current transformer and overcurrent relay, conductors shall be permitted to be tapped from the load side of the protected terminals in accordance with 240.21(B). Tapped conductors shall not be permitted for portable generators rated 15 kW or less where field wiring connection terminals are not accessible »***445.13(B)***«.

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Busways

General Installation Provisions

Busways shall not be installed as follows: (1) where subject to severe physical damage or corrosive vapors; (2) in hoistways; (3) in any hazardous (classified) location, unless specifically approved for such use; and (4) outdoors or in wet or damp locations unless identified for such use »*368.12(A) through (D)*«.

Cord and cable installations must comply with 368.56(B) and (C).

Overcurrent protection is required where busways are reduced in ampacity, unless the industrial establishment exception is met »*368.17(B)*«.

A busway used as a branch circuit shall be protected against overcurrent in accordance with 210.20 »*368.17(D)*«.

A Article 368 covers the service-entrance, feeder, branch-circuit busways, and associated fittings »*368.1*«. A busway is a raceway consisting of a metal enclosure containing factory-mounted, bare, or insulated conductors, which are usually copper or aluminum bars, rods, or tubes »*Article 100*«.

B Busways must be securely supported at no more than 5-ft (1.5-m) intervals unless otherwise designed and so marked »*368.30*«.

C Where a busway serves as a feeder, devices or plug-in connections for tapping off feeder or branch circuits from the busway shall consist of an externally operable circuit breaker or fusible switch. If such devices contain a disconnecting means and are mounted out of reach, a suitable means (ropes, chains, sticks, etc.) shall be provided to facilitate operation of the disconnecting means from the floor »*368.17(C)*«. (This section also contains four exceptions.)

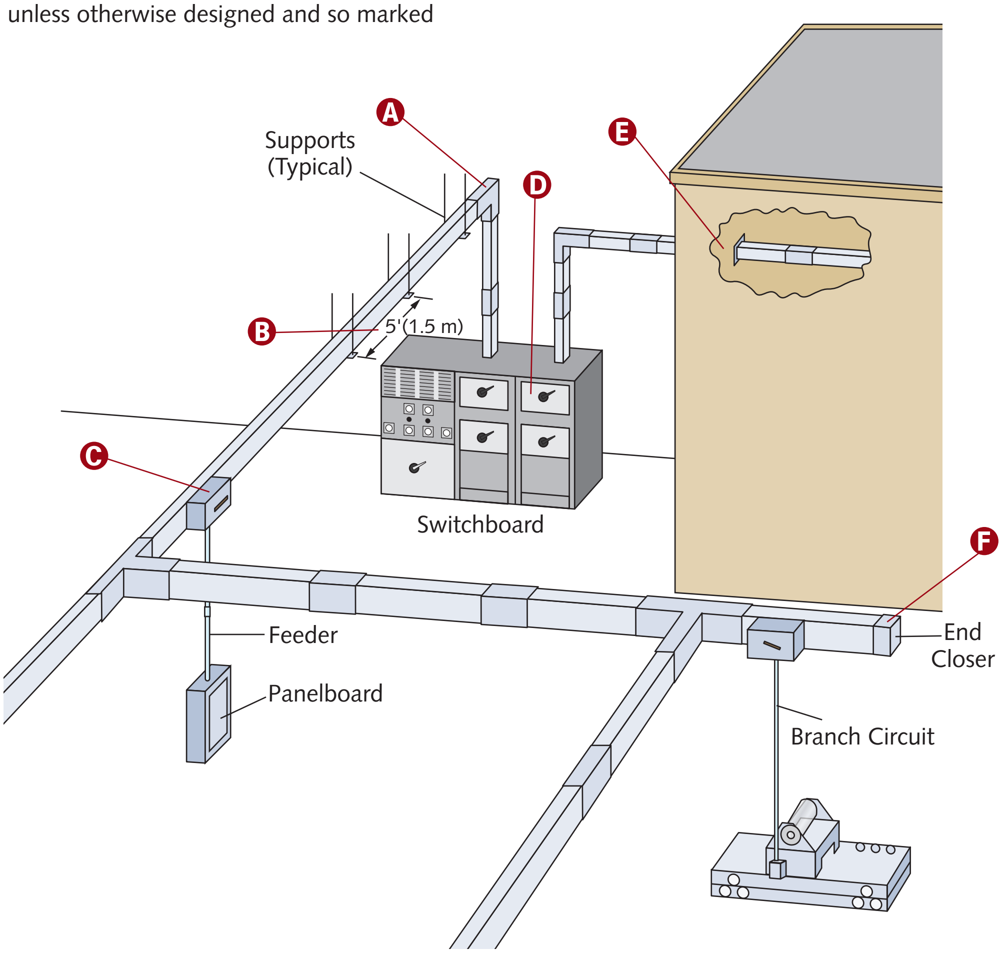
D A busway shall be protected against overcurrent in accordance with the busway's allowable current rating, unless applying the applicable provisions of 240.4 or 450.6(A)(3) »*368.17(A)*«.

E Unbroken busway lengths can extend through dry walls »*368.10(C)(1)*«.

F A busway's dead end shall be closed »*368.58*«.

Note

Lighting and trolley busways shall not be installed less than 8 ft (2.5 m) above the floor (or working platform), unless provided with an identified cover »*368.12(E)*«.



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Vertical Installation Provisions

Branches from busways shall be permitted to use any of the following wiring methods:

(1) Type AC (armored cable)
(2) Type MC (metal-clad cable)
(3) Type MI (mineral-insulated, metal-sheathed cable)
(4) IMC (intermediate metal conduit)
(5) RMC (rigid metal conduit)
(6) FMC (flexible metal conduit)
(7) LFMC (liquidtight flexible metal conduit)
(8) PVC (rigid polyvinyl chloride conduit)
(9) RTRC (reinforced thermosetting resin conduit)
(10) LFNC (liquidtight flexible nonmetallic conduit)
(11) EMT (electrical metallic tubing)
(12) ENT (electrical nonmetallic tubing)
(13) Busways
(14) Strut-type channel raceway
(15) Surface metal raceway
(16) Surface nonmetallic raceway

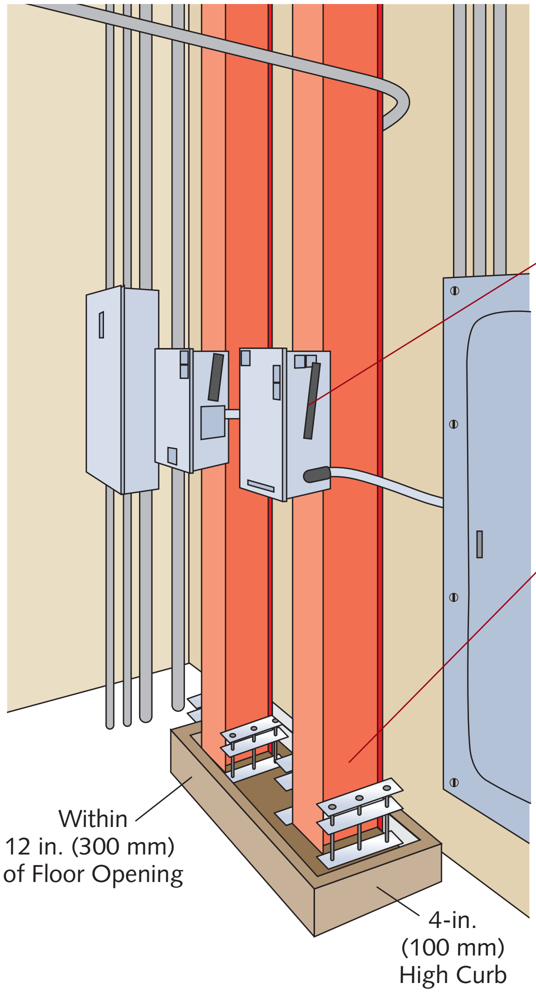
Where a separate equipment grounding conductor is used, connection of the equipment grounding conductor to the busway shall comply with 250.8 and 250.12 ››*368.56(A)*‹‹.

A Busways and busway taps shall be protected against overcurrent in accordance with 368.17 ››*240.21(E)*‹‹.

B Section 368.10(C)(2) requires that floor penetrations comply with (a) and (b):

(a) Vertical busways can extend through dry floors if totally enclosed (unventilated) where passing through, and for a minimum distance of 6 ft (1.8 m) above the floor, providing adequate physical damage protection.

(b) In other than industrial establishments, where a vertical riser penetrates multiple dry floors, a minimum 4-in. (100-mm) high curb shall be installed around all busway riser floor openings to prevent liquid penetration. The curb shall be installed within 12 in. (300 mm) of the floor opening. Locate electrical equipment so that it is not likely to be damaged by curb-retained liquids.



Note

Implement electrical installations in hollow spaces or vertical shafts so that the possible spread of fire, or products of combustion, will not be substantially increased. Openings around electrical penetrations into or through fire-resistant-rated walls, partitions, floors, or ceilings shall be firestopped by approved methods to maintain the fire resistance rating ››*300.21*‹‹.

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Summary

- Sections 225.18 and 230.24(B) contain minimum vertical wiring clearance provisions.
- Except for meters that are installed in meter sockets, associated equipment located above or below electrical equipment shall not extend more than 6 in. (150 mm) beyond the electrical equipment's front.
- A space equal to the width and depth of the equipment (panelboards, switchboards, switchgear, and motor control centers), extending from the floor to a height of 6 ft (1.8 m) above the equipment (or to the structural ceiling, whichever is lower) must be dedicated to the electrical installation.
- The space equal to the width and depth of the equipment above panelboards, switchboards, switchgear, and motor control centers must be clear of foreign systems unless protection is provided to avoid damage from condensation, leaks, or breaks.
- Working space clearances vary, depending on conditions and voltage.
- For equipment rated 1200 amperes or more and over 6 ft (1.8 m) wide and service disconnecting means where the combined ampere rating is 1200 amperes or more and over 6 ft (1.8 m) wide containing overcurrent devices, switching devices, or control devices, there shall be an entrance at each end of the working space unless meeting one of the alternative conditions.
- In switchboards, switchgear, and panelboards, every circuit and circuit modification must be legibly identified as to its clear, evident, and specific purpose or use.
- On the supply side of the service, the grounded circuit conductor and grounding conductors are connected together.
- All switchboards, switchgear, and panelboards supplied by a feeder in other than one- or two-family dwellings shall be marked to indicate the device or equipment where the power supply originates.
- A grounding connection must not be made to any grounded circuit conductor on the load side of the service disconnecting means except as otherwise allowed by Article 250.
- Transformer provisions are located in Article 450.
- Section 250.30 contains separately derived system grounding provisions.
- An alternate ac power source (such as an on-site generator) is not a separately derived system if the grounded conductor is solidly interconnected to a service-supplied grounded conductor.
- Article 368 covers service-entrance, feeder, and branch-circuit busways and associated fittings.
- It may be required to install a terminal bar inside a transformer enclosure and if so, the terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any vented portion of the enclosure.
- While a basic arc flash hazard warning label is required on electrical equipment likely to require examination, adjustment, servicing, or maintenance while energized, a permanent label is required for service and feeder supplied equipment, in other than dwelling units, rated 1000 amps or more.

Unit 14 Competency Test

***NEC*® Reference**	**Answer**	
____________	____________	1. A separately derived system's grounding electrode conductor connection can be made at any point from the source to the ____________ system disconnecting means or overcurrent device.
____________	____________	2. For the purposes of Article 408, a 3-pole circuit breaker shall be considered ____________ overcurrent device(s).
____________	____________	3. Internal parts of electrical equipment, including busbars, wiring terminals, insulators, and other surfaces, shall not be ____________ by foreign materials such as paint, plaster, cleaners, abrasives, or corrosive residues.
____________	____________	4. An alternate ac power source such as an on-site generator is not a separately derived system if the ____________ is solidly interconnected to a service-supplied system ____________.
____________	____________	5. For equipment rated 1200 amperes or more and over 6 ft wide that contains overcurrent devices, switching devices, or control devices, there shall be at least ____________ entrance(s) into the required working space.
____________	____________	6. A 480-volt transformer, equipped with coordinated thermal overload protection by the manufacturer and arranged to interrupt the primary current, shall be permitted to have primary overcurrent protection rated or set at a current value that is not more than ____________ the rated current of the transformer for a transformer having 8% impedance.

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***NEC*® Reference** **Answer**

____________ ____________ 7. The width of the working space in front of the electric equipment shall be the width of the equipment or ____________ in., whichever is greater.

____________ ____________ 8. Where field-installed wiring passes through an opening in an enclosure, conduit box, or barrier, a ____________ shall be used to protect the conductors from the edges of an opening having sharp edges within generators.

____________ ____________ 9. On a switchboard, switchgear, or panelboard supplied from a 4-wire, delta-connected system where the midpoint of one phase winding is grounded, that phase busbar or conductor having the higher voltage to ground shall be durably and permanently marked by an outer finish that is ____________ in color or by other effective means.

____________ ____________ 10. Ground-fault protection of equipment shall be provided for solidly grounded wye electric services of more than 150 volts to ground, but not exceeding 1000 volts phase-to-phase for each service disconnect rated ____________ or more.

____________ ____________ 11. The ____________ conductor of each separately derived system shall be bonded to the nearest accessible point of the interior metal water piping system(s) in the area served by each separately derived system.

____________ ____________ 12. Busways shall be securely supported at intervals not exceeding ____________ ft unless otherwise designed and marked.

____________ ____________ 13. What is the minimum vertical clearance (in ft) for 208Y/120-volt, 3-phase overhead service conductors in a commercial area subject to minimal truck traffic?

____________ ____________ 14. Covered, shielded, fenced, enclosed, or otherwise protected by means of suitable covers, casings, barriers, rails, screens, mats, or platforms to remove the likelihood of approach or contact by persons or objects to a point of danger is the definition of ____________.

____________ ____________ 15. Where the overcurrent device is rated over ____________ amperes, the ampacity of the conductors it protects shall be equal to or greater than the rating of the overcurrent device as defined in 240.6.

____________ ____________ 16. The enclosure for a panelboard shall have the top and bottom wire-bending space sized in accordance with ____________ for the largest conductor entering or leaving the enclosure.

____________ ____________ 17. A(n) ____________ is an electrical power supply output, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections.

____________ ____________ 18. Dry-type transformers 1000 volts, nominal, or less and not exceeding ____________ shall be permitted in hollow spaces of buildings not permanently closed in by structure.

____________ ____________ 19. Where rear access is required to work on nonelectrical parts on the back of enclosed equipment, a minimum horizontal working space of ____________ in. shall be provided.

____________ ____________ 20. The ampacity of the conductors from the generator output terminals to the first distribution device(s) containing overcurrent protection shall not be less than ____________ % of the nameplate current rating of the generator.

____________ ____________ 21. Other equipment that is associated with the electrical installation and is located above or below the electrical equipment shall be permitted to extend not more than ____________ in. beyond the front of the electrical equipment.

____________ ____________ 22. For industrial establishments only, omission of overcurrent protection shall be permitted at points where busways are reduced in ampacity, provided that the length of the busway having the smaller ampacity does not exceed ____________ ft and has an ampacity at least equal to one-third the rating or setting of the overcurrent device next back on the line, and provided that such busway is free from contact with combustible material.

____________ ____________ 23. Circuit breakers shall be marked with their ampere rating in a manner that will be ____________ after installation.

***NEC*® Reference** **Answer**

____________ ____________ 24. The minimum height for work space about service equipment, switchboards, switchgear, panelboards, or motor control centers shall be ____________ ft.

____________ ____________ 25. A 480Y/277-volt switchboard, having exposed live parts on one side and a concrete wall on the other side, requires a minimum working space depth of ____________ in.

____________ ____________ 26. Transformers, other than ____________, shall have a disconnecting means located either in sight of the transformer or in a remote location. Where located in a remote location, the disconnecting means shall be lockable in accordance with 110.25, and its location shall be field-marked on the transformer.

____________ ____________ 27. In other than industrial establishments, where a vertical riser penetrates two or more dry floors, a minimum ____________ in.-high curb shall be installed around all floor openings for riser busways to prevent liquids from entering the opening.

____________ ____________ 28. A large single panel, frame, or assembly of panels on which are mounted on the face, back, or both, switches, overcurrent, and other protective devices, buses, and usually instruments is called a ____________.

____________ ____________ 29. Tapped conductors shall not be permitted for portable generators rated ____________ or less where field wiring connection terminals are not accessible.

____________ ____________ 30. The space equal to the width and depth of switchboards, switchgear, panelboards, and motor control centers and extending from the floor to a height of ____________ ft above the equipment or to the structural ceiling, whichever is lower, shall be dedicated to the electrical installation.

____________ ____________ 31. For other than a totally enclosed switchboard or switchgear, a space not less than ____________ ft shall be provided between the top of the switchboard or switchgear and any combustible ceiling, unless a noncombustible shield is provided between the switchboard or switchgear and the ceiling.

____________ ____________ 32. Where the service-entrance phase conductors are larger than 1100-kcmil copper or 1750-kcmil aluminum, the main bonding jumper shall have an area that is not less than ____________ of the area of the largest phase conductor.

____________ ____________ 33. ____________ is defined as being surrounded by a case, housing, fence, or walls that prevent persons from accidentally contacting energized parts.

____________ ____________ 34. Busways shall be permitted to be extended vertically through dry floors if totally enclosed (unventilated) where passing through and for a minimum distance of ____________ ft above the floor to provide adequate protection from physical damage.

____________ ____________ 35. Where a terminal bar is installed in a dry-type transformer, the terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any ____________ of the enclosure.

____________ ____________ 36. In other than dwelling units, a permanent arc flash hazard warning label shall be field or factory applied to service equipment rated ____________ or more.

____________ ____________ 37. Transformers, other than Class 2 or Class 3 transformers, shall have a disconnecting means located either in sight of the transformer or in a remote location. Where located in a remote location, the disconnecting means shall be lockable open in accordance with ____________, and its location shall be field marked on the transformer.

____________ ____________ 38. Where electrical equipment rated ____________ amperes or more that contains overcurrent devices, switching devices, or control devices is installed and there is a personnel door(s) intended for entrance to and egress from the working space less than ____________ ft from the nearest edge of the working space, the door(s) shall open at least 90 degrees in the direction of egress and be equipped with listed panic hardware or listed fire exit hardware.

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Section 5

Special Occupancies, Areas, and Equipment

Unit 15

Hazardous (Classified) Locations

Objectives

After studying this unit, the student should be able to:

- explain what constitutes Class I, II, and III locations, as well as the parameters for Divisions 1 and 2 within each class.
- summarize provisions pertaining to commercial garages and the different types of repair garages.
- recall that Article 513 applies to buildings/structures, or parts thereof, inside which aircraft are housed, stored, serviced, repaired, or altered.
- clarify the distinction between Division 1's normal operating conditions and Division 2's abnormal operations.
- recall that Articles 500 through 504 cover requirements for electrical and electronic equipment/wiring, of all voltages, within hazardous (classified) locations with potential fire or explosion hazards due to the presence of flammable gases (or vapors), flammable liquids, combustible dust, or ignitible fibers (or flyings).
- recall that a motor fuel dispensing facility is defined as that portion of a property where motor fuels are stored and dispensed from fixed equipment into the fuel tanks of motor vehicles or marine craft or into approved containers, including all equipment used in connection therewith.
- remember to look in Article 516 to find requirements for spray application, dipping, coating, and printing processes using flammable or combustible materials.

Introduction

Hazardous (classified) locations are divided into certain categories and subcategories, otherwise known as classes and divisions. Articles 500 through 504 cover the requirements for electrical and electronic equipment/wiring, of all voltages in Class I, Divisions 1 and 2; Class II, Divisions 1 and 2; and Class III, Divisions 1 and 2 locations, where potential fire or explosion hazards exist due to the presence of flammable gases (or vapors), flammable liquids, combustible dust, or ignitible fibers (or flyings). Locations containing quantities of airborne gases (or vapors), potentially sufficient to cause explosion or ignition, are categorized as Class I. Locations hazardous due to the presence of combustible dust are designated Class II. Class III locations are hazardous due to the presence of combustible or ignitible fibers or flyings, such as rayon or cotton. Under typical (normal) operating conditions, Division 1 locations contain ignitible or combustible elements (gases, dust, fibers, etc.) in quantities sufficient to produce explosive (or ignitible) mixtures. Most locations where airborne combustible or ignitible elements (gases, dust, fibers, etc.) are not ordinarily present in quantities sufficient to produce explosive (or ignitible) mixtures are classified Division 2. Within these Articles 500 through 504, many Informational Notes reference other standards for more information on specific applications. Similarly, this text refers the reader, in this instance, to the *Code* itself for Article 504 *(Intrinsically Safe Systems)* and Article 505 *(Zone 0, 1, and 2 Locations)*. The fact that, for various reasons, this text could not address these topics is in no way intended to diminish their significance. Articles 511 through 517 cover occupancies, or parts thereof, that are or may be hazardous because of atmospheric concentrations of flammable liquids, gases, or vapors; or because of deposits or accumulations of readily ignitible materials.

Overview

Class Categorizations

A Class I locations are those in which flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures. Class I locations shall include those specified in 500.5(B)(1) and (B)(2) »*500.5(B)*«.

B Generally, under normal operating conditions, Division 1 locations contain ignitible or combustible elements (gases, dust, fibers, etc.) in quantities sufficient to produce explosive (or ignitible) mixtures.

C Equipment approved (listed or classified) for Class I locations are not automatically approved for Class II and Class III locations. Class I equipment may not operate at a safe temperature under a blanket of dust or fibers. Equipment that has been identified for a Division 1 location can be installed in a Division 2 location of the same class, group, and temperature class »*500.8(B)(2)*«.

D Class II group classifications are covered in 500.6(B).

E The Class I temperature marking specified in 500.8(C), shall not exceed the autoignition temperature of the specific gas or vapor to be encountered »*500.8(D)(1)*«. (See the Informational Note for the location of additional literature regarding gas/vapor autoignition temperatures.)

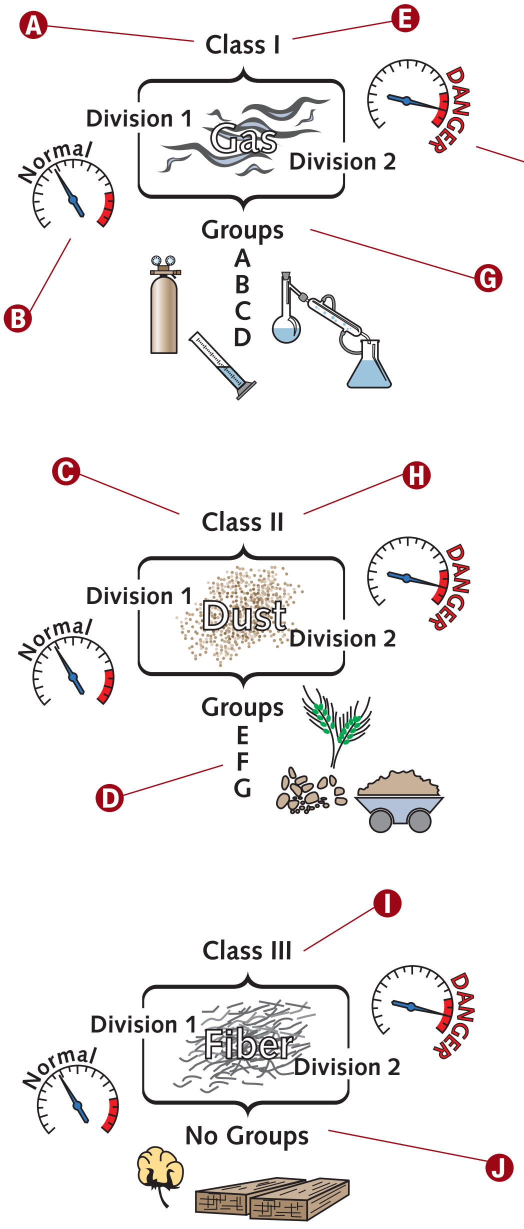
F In most cases, locations where combustible or ignitible elements (gases, dust, fibers, etc.) are not ordinarily present in the air in quantities sufficient to produce explosive (or ignitible) mixtures are Division 2 locations.

G Class I group classifications are covered in 500.6(A).

H Class II locations are those that are hazardous because of the presence of combustible dust. Class II locations shall include those specified in 500.5(C)(1) and (C)(2) »*500.5(C)*«.

I Class III locations are those that are hazardous because of the presence of combustible or ignitible fibers or flyings, such as rayon or cotton. Class III locations shall include those specified in 500.5(D)(1) and (D)(2) »*500.5(D)*«.

J There are no groups within Class III locations »*500.6(C)*«.



Note

Areas designated as hazardous (classified) locations or determined to be unclassified shall be properly documented. Such documentation shall be available to those authorized to design, install, inspect, maintain, or operate electrical equipment at that particular location »***500.4***«.

Note

Suitability of identified equipment shall be determined by one of the following: (1) equipment listing or labeling; (2) evidence of equipment evaluation from a qualified testing laboratory or inspection agency concerned with product evaluation; or (3) evidence acceptable to the authority having jurisdiction such as a manufacturer's self-evaluation or an owner's engineering judgment »***500.8(A)***«.

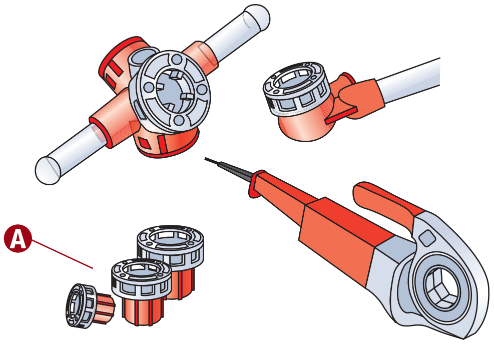
Threaded Conduit

Equipment having metric threaded entries, listed conduit fittings or listed cable fittings, shall be used. Such entries shall be identified as being metric, or listed adapters to permit connection to conduit or NPT-threaded fittings shall be provided with the equipment and shall be used for connection to conduit or NPT-threaded fittings »*500.8(E)(2)*«.

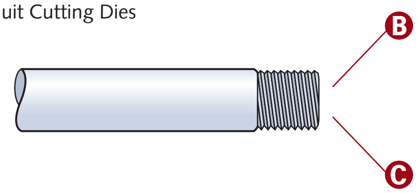
A All cut ends of intermediate metal conduit (IMC) and rigid metal conduit (RMC) shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with a ¾-in. taper per foot (1 in 16 taper) shall be used »*342.28* and *344.28*«.

B The supply connection entry thread form shall be NPT or metric. Conduit and fittings shall be made wrenchtight to prevent sparking should fault current flow through the conduit system and to ensure the explosionproof integrity of the conduit system where applicable »*500.8(E)*«.

C For equipment provided with threaded entries for NPT-threaded conduit or fittings, listed conduit, listed conduit fittings, or listed cable fittings shall be used. All NPT-threaded conduit and fittings shall be threaded with a National (American) Standard Pipe Taper (NPT) thread. NPT-threaded entries into explosionproof equipment shall be made up with at least five threads fully engaged »*500.8(E)(1)*«.



NPT Standard
Conduit Cutting Dies



Note

Threaded conduit installations must also comply with Chapter 3's requirements, in particular, Article 344 for RMC and Article 342 for IMC.

General

Article 505 covers the requirements for the zone classification system as an alternative to the division classification system covered in 500.1 for electrical and electronic equipment and wiring for all voltages where fire or explosion hazards might exist due to flammable gases, vapors, or liquids for Zone 0, Zone 1, and Zone 2 hazardous (classified) locations »*505.1(A)*«.

Except as modified in Chapter 5, all other applicable *Code* rules apply to electrical equipment/wiring installed in hazardous (classified) locations »*90.3*«.

Creative design and implementation of hazardous (classified) electrical systems may facilitate the placement of equipment in a reduced level of classification, or even nonhazardous areas, greatly reducing the risk as well as the need for special equipment »*500.5(A)(1) Informational Note*«.

Articles 511 through 517 cover garages, aircraft hangars, motor fuel dispensing facilities, bulk storage plants, spray applications, dipping/coating processes, and health care facilities. (Health care facilities are covered in Unit 16 of this book.)

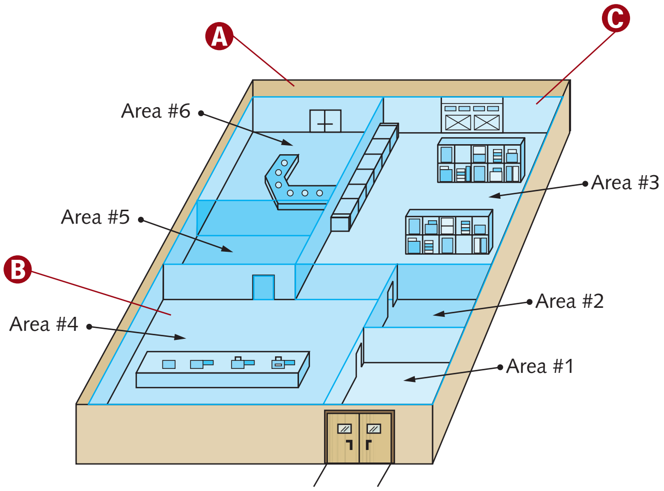
A **Scope**—Articles 500 through 504 cover the classification and requirements for electrical and electronic equipment/wiring for all voltages in Class I, Divisions 1 and 2; Class II, Divisions 1 and 2; and Class III, Divisions 1 and 2 locations where fire or explosion hazards may exist due to flammable gases (or liquid-produced vapors), combustible liquid-produced vapors, combustible dusts, or combustible or ignitible fibers (or flyings) »*500.1*, *501.1*, *502.1*, *503.1*, and *504.1*«.

B Each room, section, or area within a hazardous (classified) location shall be considered individually to determine the appropriate classification »*500.5(A)(1)*«. (Here no specific classifications are assigned for each area; they are shown for illustration purposes only.)

C Locations shall be classified depending on the properties of the flammable gas, flammable liquid–produced vapor, combustible liquid–produced vapors, combustible dusts, or fibers/flyings that could be present, and the likelihood that a flammable or combustible concentration or quantity is present »*500.5(A)(1)*«.

Note

Refer to Informational Notes 1 through 8 under 500.4 for relevant standards related to hazardous (classified) locations.



Class I Group Classifications

Hazardous (classified) locations divide atmospheric identifications for Class I, Divisions 1 and 2, locations into Groups A, B, C, and D »*500.6(A)(1) through (4)*«.

Ⓐ Group A consists of only acetylene »*500.6(A)(1)*«.

Ⓑ If, when mixed with air, a flammable/combustible gas (or liquid-produced vapor) has a maximum experimental safe gap (MESG) of no more than 0.45 mm, or a minimum igniting current ratio (MIC ratio) of no more than 0.40, the material falls into Group B »*500.6(A)(2)*«.

An example of a Class I, Group B material is hydrogen »*500.6(A)(2) Informational Note*«.

Ⓒ If, when mixed with air, a flammable/combustible gas (or liquid-produced vapor) has either an MESG value greater than 0.45 mm (but not more than 0.75 mm) or a minimum MIC ratio greater than 0.40 (but no more than 0.80), the material is classified as Group C »*500.6(A)(3)*«.

Ethylene is a typical Class I, Group C material »*500.6(A)(3) Informational Note*«.

Ⓓ Atmospheric Class I, Group D expands the limits of both the MESG (greater than 0.75 mm) value and the MIC ratio (greater than 0.80) »*500.6(A)(4)*«.

An example of a Class I, Group D material is propane »*500.6(A)(4) Informational Note No. 1*«.

Class II Group Classifications

Groups E, F, and G compose Class II hazardous atmospheres »*500.6(B)(1) through (3)*«.

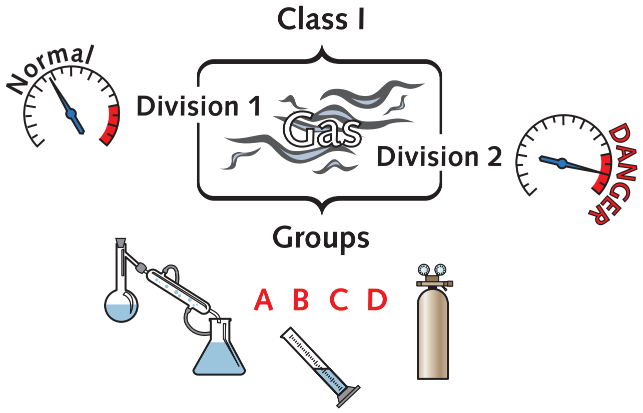
Combustible dust is defined as solid particles that are 500 micrometers or smaller (i.e., material passing a U.S. No. 35 Standard Sieve as defined in ASTM E 11-17, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves) that can form an explosible mixture when suspended in air at standard atmospheric pressure and temperature »*Article 100*«.

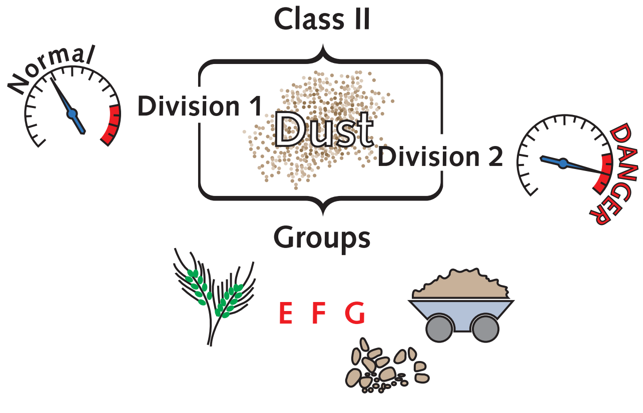
Ⓔ Group E atmospheres contain combustible metal dust whose particle size, abrasiveness, and conductivity present similar hazards in electrical equipment operation. Aluminum, magnesium, and their commercial alloys are Class II, Group E materials »*500.6(B)(1)*«.

As with Class I Groups, certain metal dust characteristics may require safeguards beyond those given here. Uranium dust, for example, may ignite at temperatures as low as 20°C (68°F) »*500.6(B)(1) Informational Note*«.

Ⓕ Potentially explosive dusts containing or yielding carbon, having more than 8% total entrapped volatiles, or having been sensitized through the action of other substances, are Group F materials. Coal, carbon black (used in the production of ink and rubber products), and charcoal are three examples of Class II, Group F items »*500.6(B)(2)*«.

Ⓖ Group G is the catchall group whose atmospheres contain combustible dusts not included in Group E or F, including flour, grain, wood, plastic, and chemicals »*500.6(B)(3)*«.





Caution

Equipment used in any location containing flammable gases/vapors shall be identified for the class, as well as for the specific group, involved »*500.6(A) Informational Note No. 1*«.

Caution

Equipment used in Class II locations shall be identified not only for the class but also for the specific group of dust that will be present »*500.6(B)(3) Informational Note No. 2*«.

Equipment

Inspection authorities and users are advised to exercise extraordinary care with regard to installation and maintenance.

Any equipment preventing the entrance of flammable/combustible fluids by means of a single compression seal, diaphragm, or tube shall be identified for a Class I, Division 2 location. Equipment installed in a Class I, Division 1 location shall be identified for the Class I, Division 1 location »*500.8(B)(4)*«.

Where Articles 501 through 503 specifically permit, general-purpose equipment or equipment in general-purpose enclosures can be installed in Division 2 locations if, under normal operating conditions, the equipment does not constitute a source of ignition »*500.8(B)(3)*«.

Where flammable gases, flammable liquid-produced vapors, combustible liquid-produced vapors, or combustible dusts are or may be present at the same time, the simultaneous presence of both shall be considered when determining the safe operating temperature of the electrical equipment »*500.8(B)(6)*«.

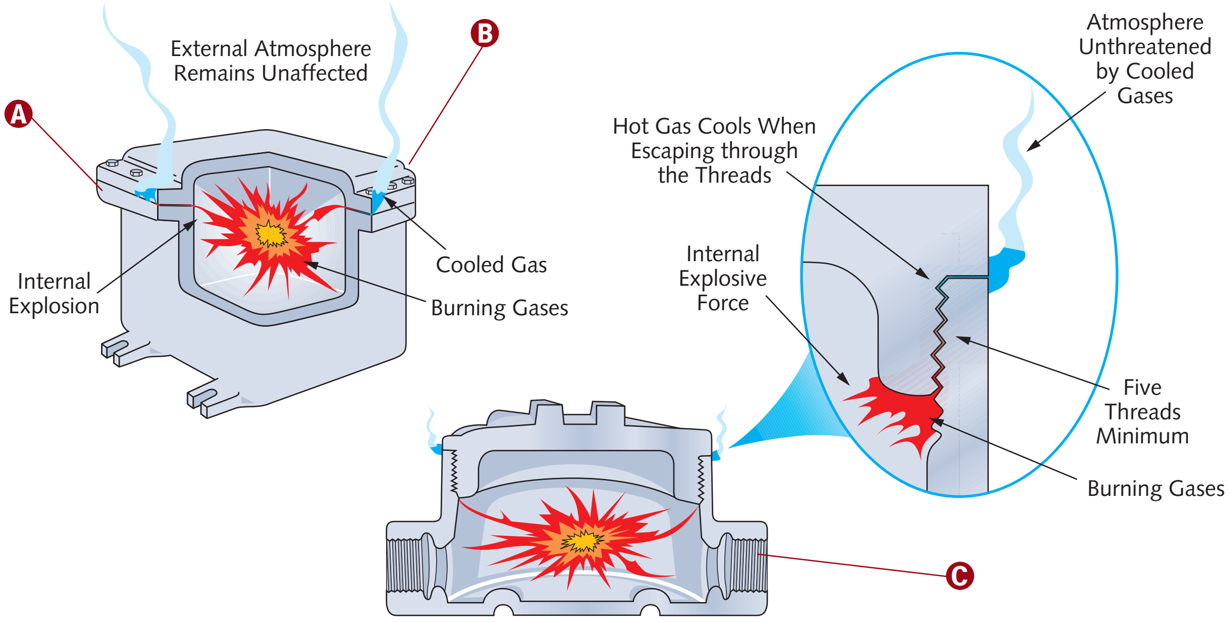
A Equipment shall be identified not only for the class of location but also for the explosive, combustible, or ignitible properties of the specific gas, vapor, dust, fiber, or flyings that will be present. In addition, Class I equipment shall not have any exposed surface operating at temperatures in excess of the autoignition temperature of the specific gas/vapor. Class II equipment shall not have an external temperature higher than that specified in 500.8(D)(2). Class III equipment shall not exceed the maximum surface temperature specified in 503.5 »*500.8(B)(1)*«.

B Articles 500 through 504 require equipment construction and installation that will ensure safe performance under conditions of proper use and maintenance.

C Equipment that has been identified for a Division 1 location can be installed in a Division 2 location of the same class, group, and temperature class »*500.8(B)(2)*«. However, the reverse is not true; that is, Division 2–approved equipment shall not be used in a Division 1 location.

Warning

All unused openings shall be closed with listed blanking elements or close-up plugs. The thread engagement shall comply with 500.8(E)(1) or 500.8(E)(2) »*500.8(E)(3)*«.

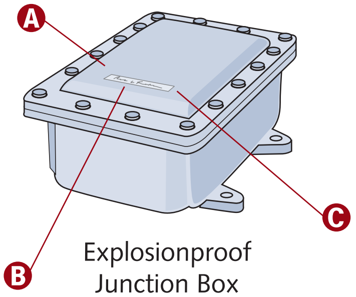

External Atmosphere Remains Unaffected
B
A
Internal Explosion
Cooled Gas
Burning Gases
Atmosphere Unthreatened by Cooled Gases
Hot Gas Cools When Escaping through the Threads
Internal Explosive Force
Five Threads Minimum
Burning Gases
C

Marking

A Equipment shall be marked to show the environment for which it has been evaluated. Unless otherwise specified in 500.8(C)(6), the markings shall include: (1) class, (2) division, (3) material classification group, (4) equipment temperature, and (5) ambient temperature range »*500.8(C)*«.

B The maximum safe operating temperature shall be marked on equipment for Class I and Class II locations, having been determined by simultaneous exposure to the combined conditions for both classes »*500.8(C)(4)*«.

C The temperature class, if provided, shall be indicated using the temperature class (T Codes) shown in Table 500.8(C)(4) »*500.8(C)(4)*«.



Explosionproof Junction Box

Note

More than one marked temperature class or operating temperature, for gases and vapors, dusts, and different ambient temperatures, may appear »***500.8(C)(4) Informational Note***«.

Note

For equipment installed in a Class II, Division 1 location, the temperature class or operating temperature shall be based on operation of the equipment when blanketed with the maximum amount of dust that can accumulate on the equipment »***500.8(C)(4)***«.

Protection Techniques

The purged and pressurized protection technique is permitted for equipment in any hazardous (classified) location for which it is identified »*500.7(D)*«.

Intrinsically safe apparatus and wiring is permitted for equipment in Class I, Division 1 or Division 2; Class II, Division 1 or Division 2; or Class III, Division 1 or 2 locations »*500.7(E)*«.

***Dusttight:* Enclosures constructed so that dust will not enter under specified test conditions »*Article 100*«.**

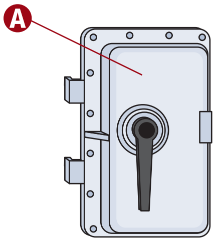
A Acceptable protection techniques for electrical and electronic equipment in hazardous (classified) locations include explosionproof equipment; dust-ignitionproof; dusttight; purged and pressurized; intrinsically safe systems; nonincendive circuit, equipment, and component; oil immersion; hermetically sealed; flammable gas detection system; and other such techniques employing equipment specifically listed for a given location »*500.7*«.

B Dusttight-designated equipment is permitted for Class II, Division 2 or Class III, Division 1 or 2 locations »*500.7(C)*«.

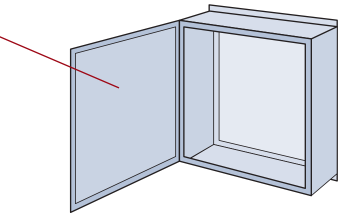
C **Explosionproof equipment** is encased by constructive design to withstand a potential internal explosion of a specified gas/vapor, effectively preventing the ignition of surrounding gas/vapors by internal sparks, flashes, or explosions and operating at such an external temperature that any surrounding flammable atmosphere will not be ignited as a result »*Article 100*«.

D Explosionproof equipment is a protection technique that is permitted for equipment in Class I, Division 1 and 2 locations »*500.7(A)*«.

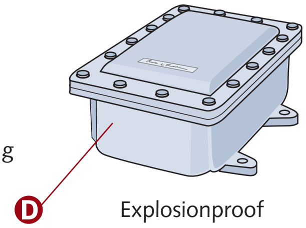
E Equipment of the dust-ignitionproof variety is acceptable for Class II, Division 1 or 2 locations »*500.7(B)*«.



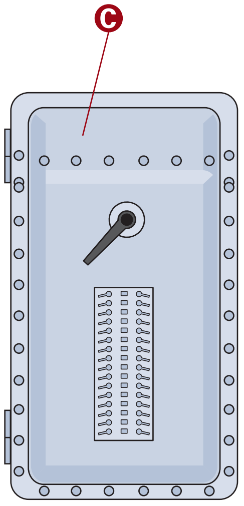
Explosionproof Enclosure for Current Interrupting Device



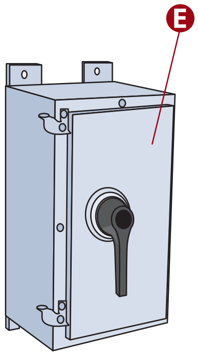
Dusttight Enclosure



Explosionproof Junction Box



Explosionproof Panelboard



Dust-Ignitionproof Enclosure for Current Interrupting Devices

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Protection Techniques *(continued)*

Nonincendive Circuit: A circuit, other than field wiring, in which any arc or thermal effect produced under the equipment's intended operating conditions is incapable, under specified test conditions, of igniting the flammable gas–, vapor–, or dust–air mixture »*Article 100*«.

Nonincendive Field Wiring: Wiring that enters or leaves an equipment enclosure and, under the equipment's normal operating conditions, is not capable, due to arcing or thermal effects, of igniting the flammable gas–, vapor–, or dust–air mixture. Normal operation includes opening, shorting, or grounding the field wiring »*Article 100*«.

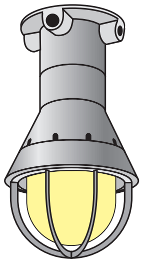
Nonincendive Equipment: Equipment having electrical/electronic circuitry that is incapable, under normal operating conditions, of causing ignition of a specified flammable gas-air, vapor-air, or dust-air mixture due to arcing or thermal means »*Article 100*«.

A nonincendive component has a contacting mechanism capable of making or breaking an incendive circuit, and the contacting mechanism is constructed so that the component is incapable of igniting the specified flammable gas–air or vapor–air mixture. A nonincendive component's housing does not exclude the flammable atmosphere nor does it contain an explosion. This protection technique is allowed for equipment in Class I, Division 2; Class II, Division 2; or Class III, Division 1 or 2 locations »*Article 100* and *500.7(H)*«.

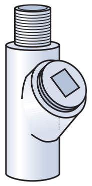
The oil-immersion protective technique is valid for current-interrupting contacts in Class I, Division 2 locations as described in 501.115(B)(1)(2) »*500.7(I)*«.

Equipment can be **hermetically sealed** against the intrusion of an external atmosphere via a fusion of metal to metal, ceramic to metal, or glass to metal »*Article 100*«.

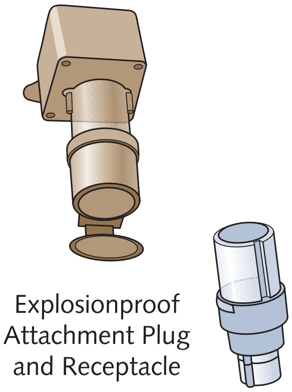
Other protection techniques inherent to equipment listed for use in hazardous (classified) locations are allowed »*500.7(U)*«.



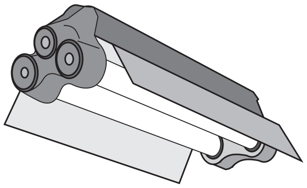
Explosionproof Incandescent Light Fixture



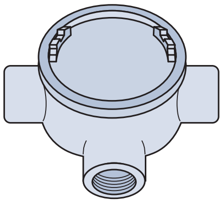
Explosionproof Vertical Seal



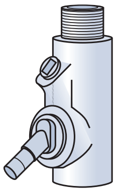
Explosionproof Attachment Plug and Receptacle



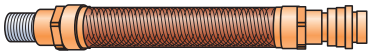
Explosionproof Fluorescent Light Fixture



Explosionproof Outlet Box



Explosionproof Vertical Seal with Drain Fitting



Explosionproof Flexible Coupling

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Class I Locations

Class I, Division 1 Locations

In addition to the specific requirements found within Article 500, general *Code* rules apply to the electric wiring and equipment in Class I locations.

In Class I, Division 1 locations, transformers and capacitors containing burnable liquid shall be installed only in approved vaults compliant with 450.41 through 450.48 in addition to all the following stipulations: (1) the vault shall not have any form of communicating opening into the Division 1 location; (2) ample ventilation shall continually remove flammable gases/vapors; (3) all vents/ducts lead to safe locations outside of buildings; and (4) vent ducts and openings shall be of sufficient area to relieve the vault's internal explosive pressures, having all portions of vent ducts (within the building) constructed of reinforced concrete »*501.100(A)(1)*«. Subsequently, transformers and capacitors not containing burnable liquids shall either be installed in 501.100(A)(1) compliant vaults or be identified for Class I locations »*501.100(A)(2)*«.

In Class I, Division 1 locations, meters, instruments, and relays, including kilowatt-hour meters, instrument transformers, resistors, rectifiers, and thermionic tubes, shall be provided with enclosures identified for Class I, Division 1 locations. Enclosures for Class I, Division 1 locations include explosionproof enclosures and purged and pressurized enclosures »*501.105(A)*«.

A Class I, Division 1 classifications usually include the following locations:

1. Where volatile flammable liquids or liquefied flammable gases are transferred from one container to another
2. Spray booth interiors and areas in the vicinity of spraying/painting operations where flammable solvents are used
3. Locations containing open tanks/vats of volatile flammable liquids
4. Drying rooms or components for the evaporation of flammable solvents
5. Locations containing fat and oil extraction equipment using volatile flammable solvents
6. Portions of cleaning and dyeing plants where flammable liquids are used
7. Gas generator rooms and other portions of gas manufacturing plants where flammable gas might escape
8. Inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids
9. Refrigerator/freezer interiors in which volatile flammable materials are stored in open, lightly stoppered, or easily ruptured containers
10. The inside of inadequately vented enclosures containing instruments normally venting flammable gases/vapors within the enclosure
11. The inside of vented tanks containing volatile flammable liquids
12. The area between the inner and outer roof sections of a floating roof tank containing volatile flammable fluids
13. Inadequately ventilated areas within spraying/coating operations using volatile flammable fluids
14. The interior of an exhaust duct used to vent ignitible concentrations of gases/vapors
15. All other locations where ignitible concentrations of flammable vapors/gases are likely to occur in the course of normal operation

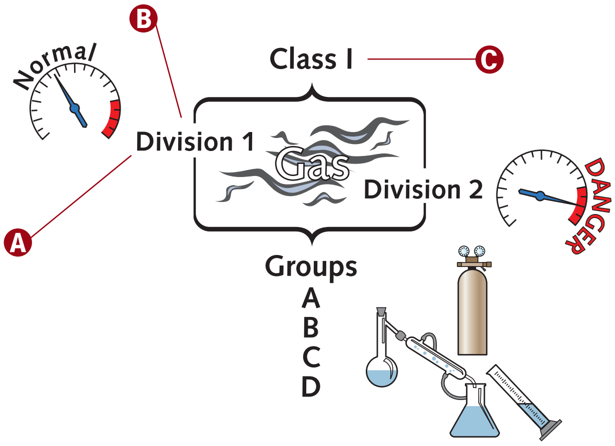
Avoiding the installation of electrical components in these areas altogether is strongly recommended. If relocation is unfeasible, use electric equipment or instrumentation approved specifically for the application, or consisting of what Article 504 describes as intrinsically safe systems »*500.5(B)(1) Informational Note*«.

B Class I, Division 1 locations contain ignitible concentrations of flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors that (1) can exist during normal operation; or (2) might often exist due to repair, maintenance, or leakage; or (3) might be released because operational failures cause simultaneous breakdowns of electrical equipment capable of becoming a source of ignition »*500.5(B)(1)*«.

C Class I locations are those in which flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures »*500.5(B)*«.

Note

Bonding and grounding must comply with 501.30(A) and (B) provisions.



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Class I, Division 2 Locations

505.9(C)(2) approved equipment, specifically listed for use in Zone 0, 1, or 2 locations, is acceptable in Class I, Division 2 locations for the same gas and with a suitable temperature class »*501.5*«.

In Class I, Division 2 locations, transformers shall comply with 450.21 through 450.27, and capacitors shall comply with 460.3 through 460.28 »*501.100(B)*«.

Where an assembly is made up of components for which general-purpose enclosures are acceptable as provided in 501.105(B)(1), (B)(2), and (B)(3), a single general-purpose enclosure shall be acceptable for the assembly. Where such an assembly includes any of the equipment described in 501.105(B)(1), 501.105(B)(2), and 501.105(B)(3), the maximum obtainable surface temperature of any component of the assembly that exceeds 100°C shall be clearly and permanently indicated on the outside of the enclosure. Alternatively, equipment shall be permitted to be marked to indicate the temperature class for which it is suitable, using the temperature class (T Code) of Table 500.8(C)(4) »*501.105(B)(1)*«.

Switches, circuit breakers, make-or-break push-button contacts, relays, and alarm bells and horns shall have enclosures identified for Class I, Division 1 locations per 501.105(A) »*501.105(B)(2)*«.

General-purpose enclosures are permitted if the current-interrupting contacts are (1) immersed in oil; (2) enclosed within a hermetically sealed chamber; (3) in nonincendive circuits; or (4) listed for Division 2 locations »*501.105(B)(2) Exception*«.

Resistors, resistance devices, thermionic tubes, rectifiers, and similar equipment used in association with meters, instruments, and relays shall comply with 501.105(A) »*501.105(B)(3)*«.

Transformer windings, impedance coils, solenoids, etc., without sliding/make-or-break contacts shall have enclosures, which may be of the general-purpose-type »*501.105(B)(4)*«.

Where general-purpose enclosures are allowed in 501.105(B)(2) through (4), they may contain overcurrent-protective fuses for instrument circuits (normally exempt from overloading), provided each fuse is preceded by a 501.105(B)(2) compliant switch »*501.105(B)(5)*«.

Flexible cord, attachment plug, and receptacle connections are acceptable for process control instruments, provided all of the following conditions are met:

1. The attachment plug and receptacle are listed for use in Class I, Division 2 locations and for use with flexible cords.
2. Unless the attachment plug and receptacle are interlocked mechanically or electrically, or otherwise designed so that they cannot be separated when the contacts are energized and the contacts cannot be energized when the plug and socket outlet are separated, a switch complying with 501.105(B)(2) is provided so that the attachment plug or receptacle is not necessary to interrupt current.
3. The flexible cord does not exceed 3 ft (900 mm) and is of a type listed for extra-hard usage or for hard usage if protected by location.
4. Only necessary receptacles are provided »*501.105(B)(6)*«.

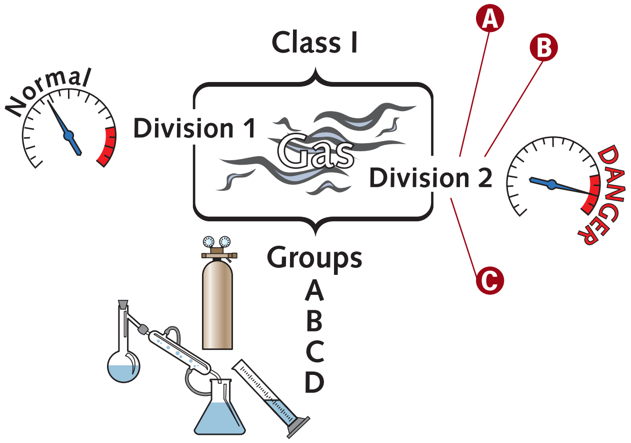
Ⓐ Class I, Division 2 locations (1) are areas where volatile flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are handled, processed, or used, but the potentially volatile substance (liquid, gas, vapor) is normally enclosed (containers or systems) and is subject to escape only during accidental rupture (or breakdown) of such enclosures or in case of abnormal conditions; (2) are equipped with positive mechanical ventilation that normally prevents the buildup of gas/vapor concentrations to an ignition level; and (3) are adjacent to a Class I, Division 1 location that might communicate ignitible gaseous concentrations unless prevented by adequate positive-pressure ventilation from a clean air source, with adequate safeguards against ventilation failure »*500.5(B)(2)*«.

Ⓑ Class I, Division 2 classification usually includes locations where volatile flammable liquids/gases, or vapors are used but that, in the judgment of the AHJ, would become hazardous only in case of an accident or unusual operating condition. The quantity of flammable material accidentally escaping, adequacy of ventilating equipment, total area involved, and the industry/business record with respect to explosions (or fires) are all factors that merit consideration in determining each location's classification and extent »*500.5(B)(2) Informational Note No. 1*«.

Ⓒ Piping without valves, checks, meters, and similar devices would not ordinarily introduce a hazard even though used for flammable liquids or gases. Depending on factors such as quantity and size of containers and ventilation, locations used for the sealed-container storage of flammable liquids or liquefied or compressed gases might be considered either hazardous (classified) or unclassified locations »*500.5(B)(2) Informational Note No. 2*«.

Note

Bonding and grounding must comply with 501.30(A) and (B) provisions.



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Wiring Methods—Class I, Division 1

Avoid tensile stress at Type MI cable termination fittings through proper installation and support methods »*501.10(A)(1)(3)*«.

PVC conduit, RTRC conduit, and HDPE conduit can be used when first surrounded by at least 2 in. (50 mm) of concrete, followed by a minimum cover of 24 in. (600 mm) (top of conduit to grade). In some cases, 514.8(C) or 515.8(A) permit the omission of the concrete encasement »*501.10(A)(1)(2)*«.

Threaded metal conduit (either rigid or steel intermediated) shall comprise the last 24 in. (600 mm) of a rigid nonmetallic underground conduit. This measurement ends at either the point of emergence or the point of aboveground raceway connection. An equipment grounding conductor is required for the dual purpose of providing raceway system electrical continuity, as well as grounding of non-current-carrying metal parts »*501.10(A)(1)(2)*«.

A NPT threaded entries into explosionproof equipment shall fully engage at least five threads »*500.8(E)(1)*«.

B Fixed wiring in Class I, Division 1 locations shall consist of threaded metal conduit, either rigid metal or steel intermediate metal, or Type MI cable terminated with fittings listed for the location. In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, listed Types MC-HL, ITC-HL, TC-ER-HL, and IM cables under certain conditions are also permitted, as well as optical fiber cable types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC »*501.10(A)(1)*«.

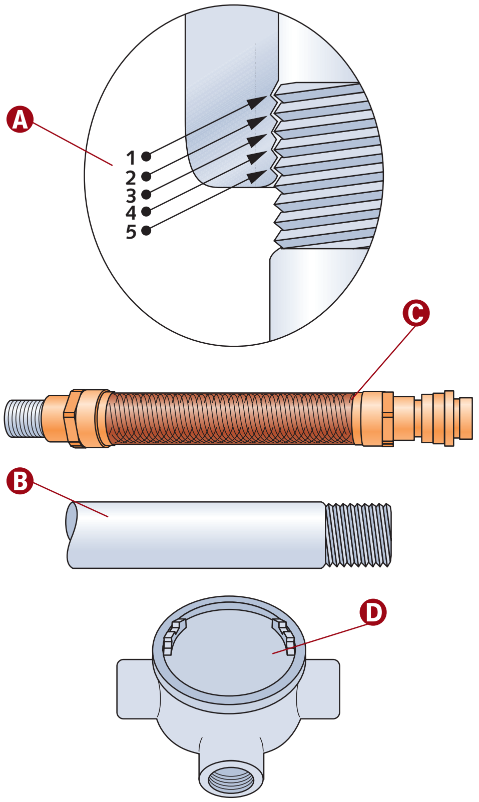
C Where necessary to employ flexible connections, as at motor terminals, one of the following shall be permitted:

(1) Flexible fittings listed for the location

(2) Flexible cord in accordance with the provisions of 501.140, terminated with cord connectors listed for the location

(3) In industrial establishments with restricted public access, where the conditions of maintenance and supervision ensure that only qualified persons service the installation, for applications limited to 600 volts, nominal, or less, and where not subject to physical damage and is terminated with fittings listed for the location, listed Type TC-ER-HL cable listed for use in Class I, Division 1 or Zone 1 locations installed in accordance with 336.10 »*501.10(A)(2)*«.

D All boxes and fittings shall be identified for Class I, Division I »*501.10(A)(3)*«.



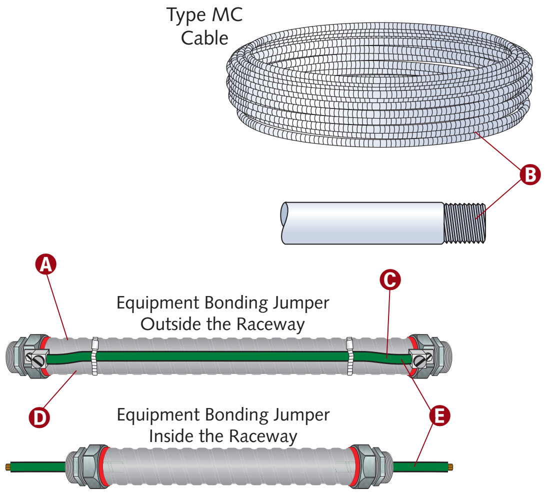
Wiring Methods—Class I, Division 2

Explosionproof boxes and fittings are not mandatory unless required by 501.105(B)(2), 501.115(B)(1), or 501.150(B)(1) »*501.10(B)(4)*«.

Nonincendive field wiring is permitted using any of the methods suitable for wiring in unclassified locations »*501.10(B)(3)*«.

A Where provisions must be made for flexibility, one of the following can be used: listed flexible metal fittings, flexible metal conduit with listed fittings, interlocked armor Type MC cable with listed fittings, liquidtight flexible metal conduit with listed fittings, liquidtight flexible nonmetallic conduit with listed fittings, or flexible cord listed for extra-hard usage and terminated with listed fittings. Flexible cord shall include a conductor for use as an equipment grounding conductor. For elevator use, an identified elevator cable of Type EO, ETP, or ETT, shown under the "use" column in Table 400.4 for "hazardous (classified) locations" and terminated with listed fittings. In restricted industrial establishments, listed Type P cable with or without metal braid armor, with an overall jacket, terminated with listed fittings in accordance with Part II of Article 337 shall be permitted. »*501.10(B)(2)*«.

B In Class I, Division 2 locations, all wiring methods permitted in 501.10(A) and the following wiring methods are permitted: (1) Rigid metal conduit (RMC) and intermediate metal


Type MC Cable
B
A
C
Equipment Bonding Jumper Outside the Raceway
D
E
Equipment Bonding Jumper Inside the Raceway

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Wiring Methods—Class I, Division 2 *(continued)*

conduit (IMC) with listed threaded or threadless fittings; (2) enclosed gasketed busways/wireways; (3) Type PLTC and Type PLTC-ER cable used for Class 2 and Class 3 circuits, including installations in cable tray systems (the cable shall be terminated with listed fittings); (4) Type ITC and Type ITC-ER cable as permitted in 335.4 and terminated with listed fittings; (5) Type MC, MV, TC or TC-ER cable, including installations in cable tray systems (the cable shall be terminated with listed fittings); (6) where metal conduit will not provide sufficient corrosion resistance listed reinforced thermosetting resin conduit (RTRC) marked with the suffix -XW, PVC-coated rigid metal conduit (RMC), PVC-coated intermediate metal conduit (IMC), and in industrial establishments with restricted public access, Schedule 80 PVC conduit; (7) Optical fiber cable Types OFNP, OFCP, OFNR, OFCR, OFNG, OFCG, OFN, and OFC shall be permitted to be installed in cable trays or any other raceway in accordance with 501.10(B). Optical fiber cables shall be sealed in accordance with 501.15; (8) Cablebus; and (9) In industrial establishments with restricted public access, listed Type P cable with an overall jacket and terminated with fittings listed for the location and installed in accordance with Part II of Article 337 »*501.10(B)(1)*«.

Ⓒ See 501.30(B)(2) for grounding requirements where flexible conduit is used.

Ⓓ Flexible metal conduit and liquidtight flexible metal conduit shall include an equipment bonding jumper of the wire type in compliance with 250.102 »*501.30(B)(2)(a)* and *505.30(B)(2)(a)*«.

Ⓔ Bonding jumpers or conductors and equipment bonding jumpers shall be permitted to be installed inside or outside of a raceway or an enclosure.

(1) **Inside a Raceway or an Enclosure.** If installed inside a raceway, equipment bonding jumpers and bonding jumpers or conductors shall comply with the requirements of 250.119 and 250.148.

(2) **Outside a Raceway or an Enclosure.** If installed on the outside, the length of the bonding jumper or conductor or equipment bonding jumper shall not exceed 6 ft (1.8 m) and shall be routed with the raceway or enclosure »*250.102(E)*«.

Conduit and Cable Seals—Class I, Divisions 1 and 2

Ⓐ Seals in conduit and cable systems, within Class I, Divisions 1 and 2 shall comply with 501.15(A) through (F) »*501.15*«.

Ⓑ The cross-sectional area of the conductors or optical fiber tubes (metallic or nonmetallic) permitted in a seal shall not exceed 25% of the cross-sectional area of a rigid metal conduit of the same trade size unless the seal is specifically identified for a higher percentage of fill »*501.15(C)(6)*«.

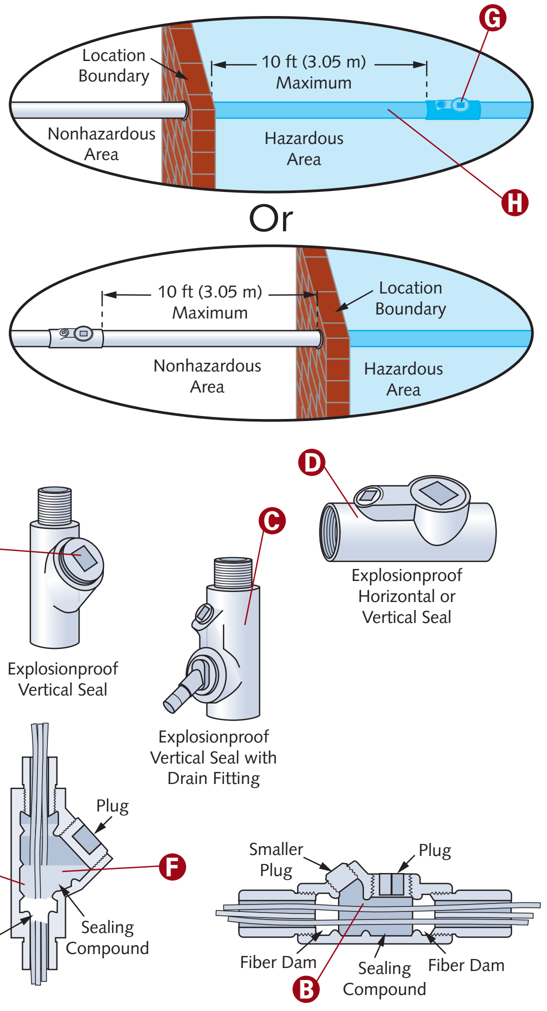
Ⓒ If a probability exists that liquid or other condensed vapor may be trapped within control equipment enclosures, or at any point in the raceway system, install approved means to prevent accumulation or to permit periodic draining »*501.15(F)(1)*«.

Ⓓ Conduit/cable system seals minimize the passage of gas/vapors and prevent the passage of flames from one portion of the electrical installation to another through the conduit »*501.15 Informational Note No. 1*«.

Ⓔ The thickness of the sealing compound installed in completed seals, other than listed cable sealing fittings, shall at least equal the trade size of the sealing fitting; however, in no case shall the thickness of the compound be less than ⅝ in. (16 mm) »*501.15(C)(3)*«.

Ⓕ The compound shall provide a seal to minimize the passage of gas and/or vapors through the sealing fitting and shall not be affected by the surrounding atmosphere or liquids. The melting point of the compound shall not be less than 93°C (200°F) »*501.15(C)(2)*«.

Ⓖ A conduit seal shall be required in each conduit run leaving a Division 1 or 2 location. The sealing fitting shall be permitted to be installed on either side of the boundary within 10 ft (3.05 m) of the boundary, and it shall be designated and installed to minimize the amount of gas or vapor within the



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Conduit and Cable Seals—Class I, Divisions 1 and 2 *(continued)*

portion of the conduit installed in the Division 1 or 2 location that can be communicated beyond the seal »*501.15(A)(4)* and *501.15(B)(2)*«.

Ⓗ The conduit run between the conduit seal and the point at which the conduit leaves the Division 1 or 2 location shall contain no union, coupling, box, or other fitting except for a listed explosionproof reducer installed at the conduit seal »*501.15(A)(4)* and *501.15(B)(2)*«.

Caution

Sealing fittings shall be listed for use with one or more specific compounds and shall be accessible »*501.15(C)(1)*«.

Note

Study 501.15 carefully, because many exceptions and informational notes are contained therein.

Type MI cable termination fittings shall contain sealing compound that excludes moisture/fluids from the cable insulation »*501.15*«.

In Class I, Division 1 locations, conduit seals shall be placed in each conduit entry into an explosionproof enclosure where the following conditions apply: (1) the enclosure contains apparatus, such as switches, circuit breakers, fuses, relays, or resistors, that may produce arcs, sparks, or temperatures that exceed 80% of the autoignition temperature, in degrees Celsius, of the gas or vapor involved in normal operation, (2) the entry is trade size 2 or larger and the enclosure contains terminals, splices, or taps »*501.15(A)(1)*«.

Class I, Division 2 connections to required explosionproof enclosures shall have a conduit seal in accordance with 501.15(A)(1)(1) and (A)(3). The entire conduit run or nipple between the seal and enclosure shall comply with 501.10(A) »*501.15(B)(1)*«.

Splices/taps shall not be made in fittings intended only for sealing with compound, nor can other fittings that contain splices/taps be filled with compound »*501.15(C)(4)*«.

Commercial Garages, Repair, and Storage

Article 514 requirements apply to fuel-dispensing units (other than liquid petroleum gas, which is prohibited) located within buildings »*511.4(B)(1)*«.

Within Class I locations as classified in 511.3, wiring shall conform to applicable Article 501 or 504.20 provisions »*511.4(A)*«.

Seals conforming to 501.15 and 501.15(B)(2) provisions shall be provided and shall apply not only to horizontal but also to vertical boundaries of the defined Class I locations »*511.9*«.

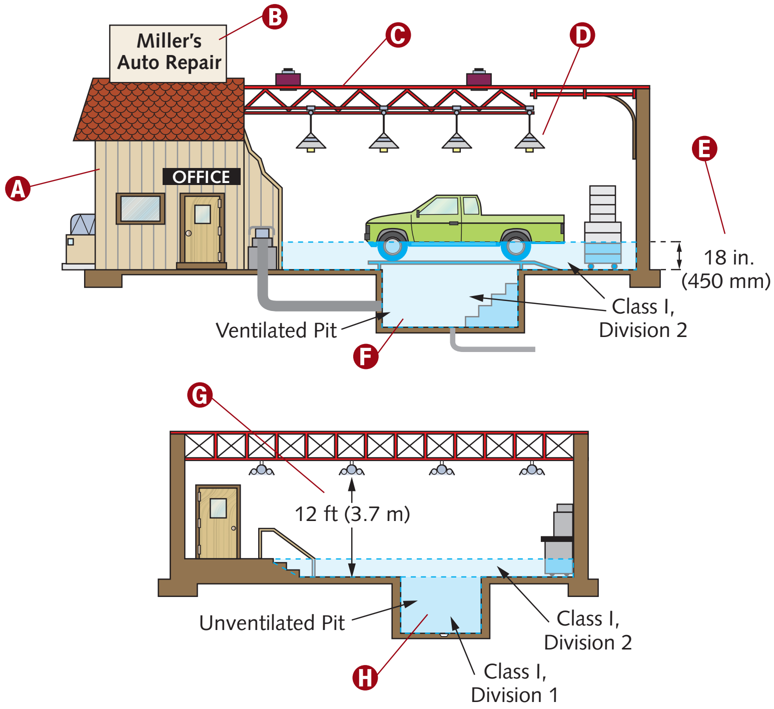
Equipment less than 12 ft (3.7 m) above the floor level installed above Class I locations that might produce arcs, sparks, or hot metal particles (such as cutouts, switches, charging panels, generators, motors, or other equipment and excluding receptacles, lamps, and lampholders) having make-or-break or sliding contacts, shall be of the totally enclosed type or constructed to prevent the escape of sparks or hot metal particles »*511.7(B)(1)(a)*«.

Ⓐ Areas adjacent to classified locations in which flammable vapor release is unlikely (such as stock rooms, switchboard rooms, and similar locations), shall be unclassified where (1) mechanically ventilated at a rate of four (or more) air changes per hour; (2) designed with positive air pressure; or (3) separated by an unpierced wall, roof, or other solid partition »*511.3(E)(1)*«.

Ⓑ A **major repair garage** is a building or portions of a building where major repairs, such as engine overhauls, painting, body and fender work, welding or grinding, and repairs that require draining of the motor vehicle fuel tank are performed on motor vehicles, including associated floor space used for offices, parking, or showrooms »*Article 100*«.

Ⓒ Article 511 occupancies include those used for service and repair of self-propelled vehicles (including, but not limited to, passenger automobiles, buses, trucks, and tractors) that use volatile flammable liquids or flammable gases for fuel or power »*511.1*«.

Ⓓ For pendants, flexible cord suitable for the type of service and listed for hard usage shall be used »*511.7(A)(2)*«.



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Commercial Garages, Repair, and Storage *(continued)*

E In major repair garages, unless there is mechanical ventilation meeting the specifications in Table 511.3(C), the entire floor area up to a level of 18 in. (450 mm) above the floor shall be classified as Class I, Division 2 »*Table 511.3(C)*«.

F Entire space within any pit, belowgrade work area, or subfloor work area that is provided with ventilation of at least 1 $ft^3/min/ft^2$ (0.3 $m^3/min/m^2$) of floor area, with suction taken from a point within 12 in. (300 mm) of floor level is a Class I, Division 2 location »*Table 511.3(C)*«.

G Lamps and lampholders for fixed lighting that are located over lanes through which vehicles are commonly driven or that might otherwise be exposed to physical damage shall be located at least 12 ft (3.7 m) above floor level, unless totally enclosed or constructed to prevent the escape of sparks or hot metal particles »*511.7(B)(1)(b)*«.

H In major repair garages, unless there is mechanical ventilation meeting the specifications in Table 511.3(C), the pit or depression below floor level and extending up to the floor level shall be a Class I, Division 1 location »*Table 511.3(C)*«.

Caution

All 125-volt through 250-volt receptacles supplied by single-phase branch circuits rated 150 volts or less to ground, 50 amperes or less, and all receptacles supplied by three-phase branch circuits rated 150 volts or less to ground, 100 amperes or less installed in a garage, accessory building, service bay, or similar area other than vehicle exhibition halls and showrooms must be GFCI protected »*210.8(B)(10)*«.

Note

In a major repair garage, up to 18 in. (450 mm) above floor level of the room where room is provided with ventilation of at least 1 $ft^3/min/ft^2$ (0.3 $m^3/min/m^2$) of floor area, with suction taken from a point within 12 in. (300 mm) of floor level shall be unclassified »***Table 511.3(C)***«.

Any circuit in a Class I location supplying portables (or pendants) that include a grounded conductor (per 200.3) shall have receptacles, attachment plugs, connectors, and similar devices of the grounding type, and the flexible cord's grounded conductor shall either be connected to the screw shell of any lampholder or to the grounded terminal of any utilization equipment supplied. Equipment grounding conductor continuity (between the fixed wiring system and the non-current-carrying metal portions of pendant luminaires, portable lamps, and portable utilization equipment) shall be maintained via approved means »*511.16(B)(1)* and *(2)*«.

Battery chargers, their control equipment, and batteries being charged shall not be located within areas classified in 511.3 »*511.10(A)*«.

All metal raceways, the metal armor or metallic sheath on cables, and all non-current-carrying metal parts of fixed/portable electrical equipment, regardless of voltage, shall be grounded »*511.16(A)*«.

A All fixed wiring above Class I locations shall be one or more of the following: (1) RMC, IMC, or EMT; (2) PVC, RTRC, or ENT; (3) FMC, LFMC, or LFNC; (4) Types MC, AC, TC, or TC-ER cables, including installation in cable trays; (5) MI cable; (6) manufactured wiring systems; (7) Type PLTC or PLTC-ER cable in Class 1, 2, or 3 circuits; (8) Type ITC or ITC-ER cable in accordance with 335.4 and 335.5; or (9) cellular metal or cellular concrete floor raceways used only for supplying outlets or extensions to the area below the floor. Such raceways shall have no connection leading into or through any Class I location above the floor. Types TC-ER, PLTC-ER, and ITC-ER cables must include an equipment grounding conductor in addition to any drain wire »*511.7(A)(1)*«.

B A **minor repair garage** is a building or portions of a building used for lubrication, inspection, and minor automotive maintenance work, such as engine tune-ups, replacement of parts, fluid changes (e.g., oil, antifreeze, transmission fluid, brake fluid, or air-conditioning refrigerants), brake system repairs, tire rotation, and similar routine maintenance work, including associated floor space used for offices, parking, or showrooms »*Article 100*«.

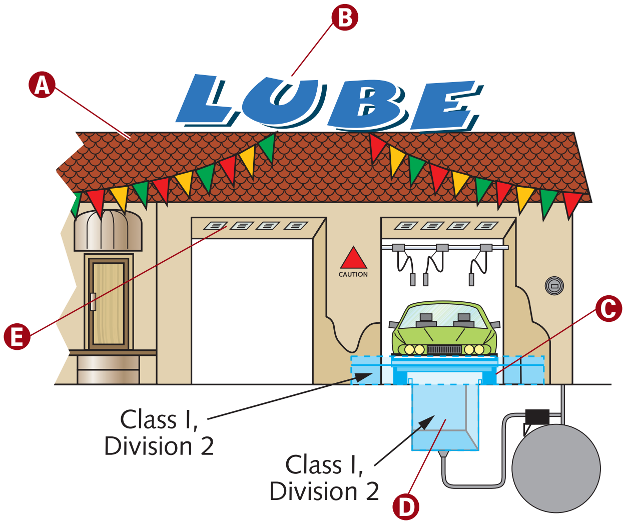
C The floor area up to a level of 18 in. (450 mm) above any unventilated pit, belowgrade work area, or subfloor work area and extending a distance of 3 ft (0.9 m) horizontally in all directions from the opening, shall be classified as Class I, Division 2 in a minor repair garage »*Table 511.3(C)*«.

D In minor repair garages, unless there is ventilation meeting the specifications in Table 511.3(C), any pit or depression below floor level and extending up to the floor level shall be a Class I, Division 2 location »*Table 511.3(C)*«.

E In major repair garages where vehicles using lighter-than-air gaseous fuels (such as hydrogen and natural gas) are repaired or stored, hazardous area classification guidance is found in Table 511.3(D) »*511.3(D)*«.

Note

In major repair garages, areas adjacent to classified locations where flammable vapors are not likely to be released, such as stock rooms, switchboard rooms, and other similar locations, where mechanically ventilated at a rate of four or more air changes per hour or designed with positive air pressure or where effectively cut off by walls or partitions shall be unclassified »***Table 511.3(C)***«.



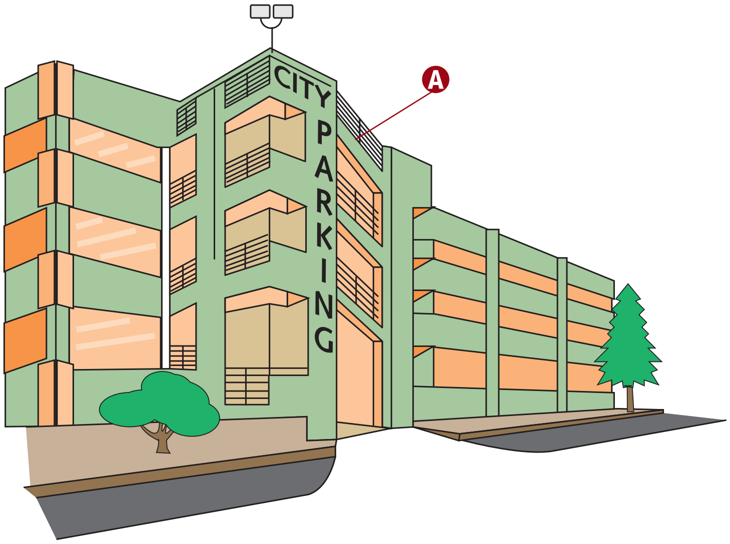
Note

In specific areas adjacent to classified locations, areas adjacent to classified locations where flammable vapors are not likely to be released, such as stock rooms, switchboard rooms, and other similar locations, where mechanically ventilated at a rate of four or more air changes per hour or designed with positive air pressure, or where effectively cut off by walls or partitions shall be unclassified »***Table 511.3(C)***«.

Parking Garages

For further information, see NFPA 88A, Standard for Parking Structures, and NFPA 30A, Code for Motor Fuel Dispensing Facilities and Repair Garages »*511.3(A) Informational Note*«.

Ⓐ Garages used for parking or storage are permitted to be unclassified »*511.3(A)*«.



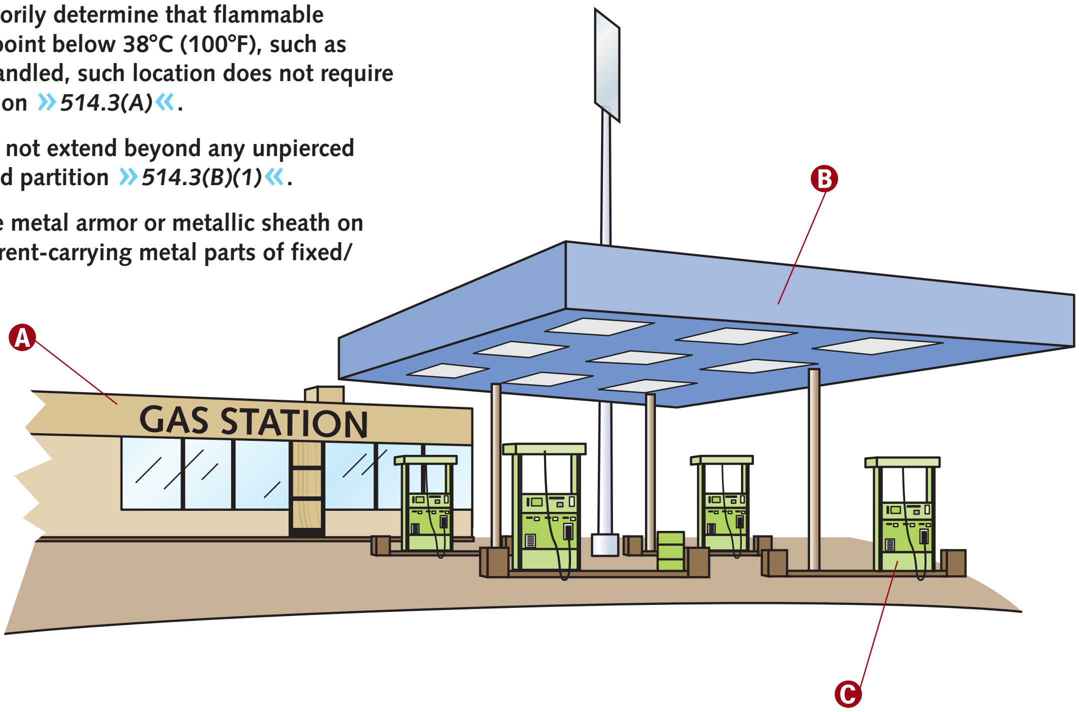
Motor Fuel Dispensing Facilities

Article 514 covers requirements applicable to motor fuel dispensing facilities, marine/motor fuel dispensing facilities, motor fuel dispensing facilities located inside buildings, and fleet vehicle motor fuel dispensing facilities »*514.1*«.

If the AHJ can satisfactorily determine that flammable liquids having a flash point below 38°C (100°F), such as gasoline, will not be handled, such location does not require a hazardous classification »*514.3(A)*«.

A Class I location does not extend beyond any unpierced wall, roof, or other solid partition »*514.3(B)(1)*«.

All metal raceways, the metal armor or metallic sheath on cables, and all non-current-carrying metal parts of fixed/portable electrical equipment, regardless of voltage, shall be grounded and bonded. Grounding and bonding in Class I locations shall comply with 501.30 »*514.16*«.



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Motor Fuel Dispensing Facilities *(continued)*

A A **motor fuel dispensing facility** is that portion of a property where motor fuels are stored and dispensed from fixed equipment into fuel tanks of motor vehicles, marine craft, or into approved containers, including all equipment used in connection with motor fuel »*Article 100*«.

B Wiring and equipment above hazardous (classified) locations classified in 514.3 shall comply with 514.7 »*514.7*«. The wiring methods permitted for motor fuel dispensing facilities are identical to those allowed for commercial garages. See page 369 for a complete list.

C All electrical equipment/wiring in the hazardous (classified) locations specified in 514.3 shall comply with Parts II and III of Article 501 »*514.4*«.

Note

Table 514.3(B)(1) shall be used where Class I liquids are stored, handled, or dispensed and to delineate and classify motor fuel dispensing facilities and commercial garages as defined in Article 100 »***514.3(B)(1)***«.

Note

Requirements for motor fuel dispensing stations in boatyards, marinas, floating docks, piers, and wharfs are in 514.(3)(C).

Dispensing Devices

At unattended motor fuel dispensing facilities, the devices or disconnects shall be readily accessible to patrons and at least one additional device or disconnect shall be readily accessible to each group of dispensing devices on an individual island »*514.11(C)*«.

At attended motor fuel dispensing facilities, the devices or disconnects shall be readily accessible to the attendant »*514.11(B)*«.

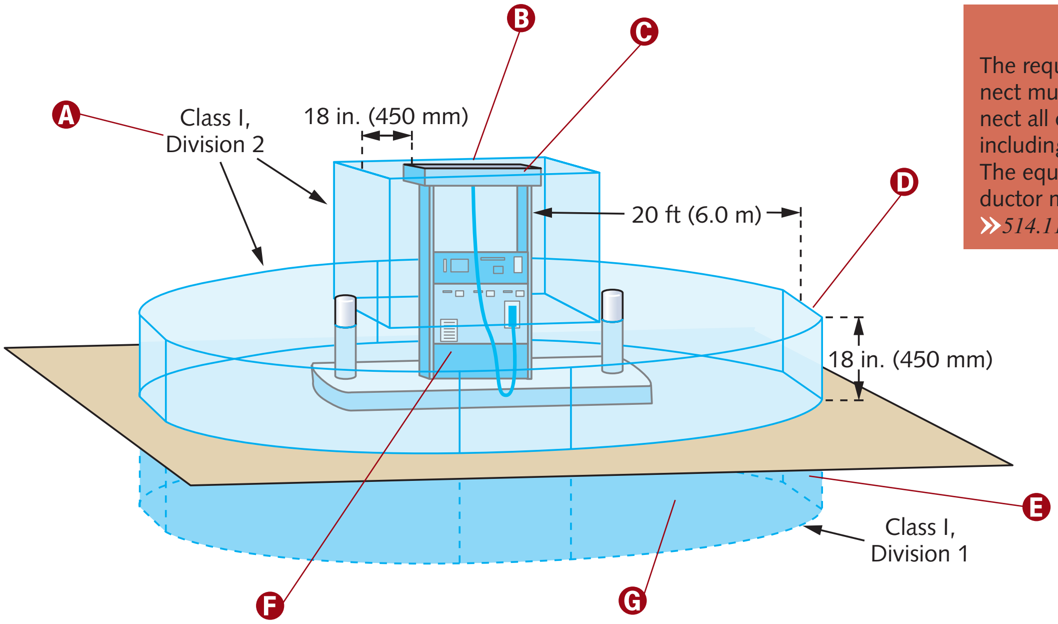
Additional seals apply to horizontal as well as vertical boundaries of the Class I locations »*514.9(B)*«.

A Within 18 in. (450 mm) of dispenser enclosure or that portion of dispenser enclosure containing liquid-handling components, extending horizontally in all directions and down to grade level is a Class I, Division 2 location »*Table 514.3(B)(1)*«.

B The space within and under the dispenser enclosure is a Class I, Division 1 location »*Table 514.3(B)(1)*«.

C Fuel dispensing systems shall be provided with one or more clearly identified emergency shutoff devices or electrical disconnects. Such devices or disconnects shall be installed in approved locations but not less than 20 ft (6 m) or more than 100 ft (30 m) from the fuel dispensing devices that they serve. Emergency shutoff devices or electrical disconnects shall disconnect power to all dispensing devices; to all remote pumps serving the dispensing devices; to all associated power, control, and signal circuits; and to all other electrical equipment in the hazardous (classified) locations surrounding the fuel dispensing devices. When more than one emergency shutoff device or electrical disconnect is provided, all devices shall be interconnected. Resetting from an emergency shutoff condition shall require manual intervention and the manner of resetting shall be approved by the authority having jurisdiction »*514.11(A)*«.

D From grade level up to a height of 18 in. (450 mm) within 20 ft (6.0 m) horizontally of any enclosure edge, is a Class I, Division 2 location »*Table 514.3(B)(1)*«.



Caution

The required emergency disconnect must simultaneously disconnect all conductors of the circuits, including the grounded conductor. The equipment grounding conductor must remain connected »*514.11(A)*«.

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Dispensing Devices *(continued)*

E All or part of any pit, box, or space below grade level within 10 ft (3m) horizontally from any edge of a remote pump is designated Class I, Division 1 »*Table 514.3(B)(1)*«.

F A listed seal shall be provided in each conduit run entering/leaving a dispenser or any cavities (or enclosures) in direct communication with the dispensing area. The sealing fitting or listed explosionproof reducer at the seal shall be the first fitting after the conduit emerges from the earth or concrete »*514.9(A)*«.

G Underground wiring shall be installed either in threaded RMC or threaded steel IMC. Any portion of electrical wiring below the surface of a Class I, Division 1 or 2 location shall be sealed within 10 ft (3.05 m) of the point of emergence above grade. Except for listed explosionproof reducers, at the conduit seal there shall be no union, coupling, box, or fitting between the conduit seal and the point of emergence above grade »*514.8*«.

Note

Each dispensing device shall be provided with a means to remove all external voltage sources, including power, communications, data, and video circuits and including feedback, during periods of maintenance and service of the dispensing equipment. The location of this means shall be permitted to be other than inside or adjacent to the dispensing device. The means shall be capable of being locked in the open position in accordance with 110.25 »***514.13***«.

Note

Underground wiring for motor fuel dispensing facilities may also be Type MI cable if installed in accordance with Part II of Article 332 or approved nonmetallic conduits where buried under not less than 2 ft (600 mm) of cover and threaded metal conduit is used for the last 2 ft of the underground run »***514.8(B)* and *(C)***«.

Aircraft Hangars

Mobile Equipment: **Equipment with electrical components that is suitable to be moved only with mechanical aids or is provided with wheels for movement by a person(s) or powered devices »*Article 100*«.**

All wiring and equipment intended for installation that is installed or operated within any of the 513.3 defined hazardous (classified) locations shall comply with the applicable provisions of the hazardous (classified) locations »*513.4(A)*«.

Attachment plugs and receptacles in Class I locations shall either be identified for the location or designed so that they shall not be energized during connection/disconnection »*513.4(A)*«.

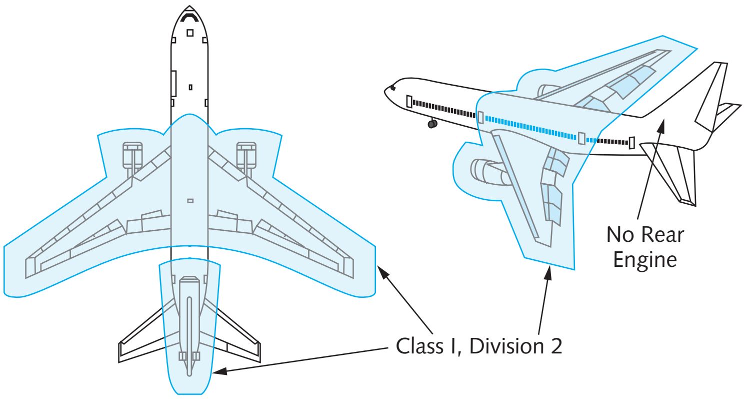
All fixed wiring in a hangar not within a Class I location as defined in 513.3 shall be (1) installed in metal raceways or (2) Type MI, TC, or MC cable »*513.7(A)*«.

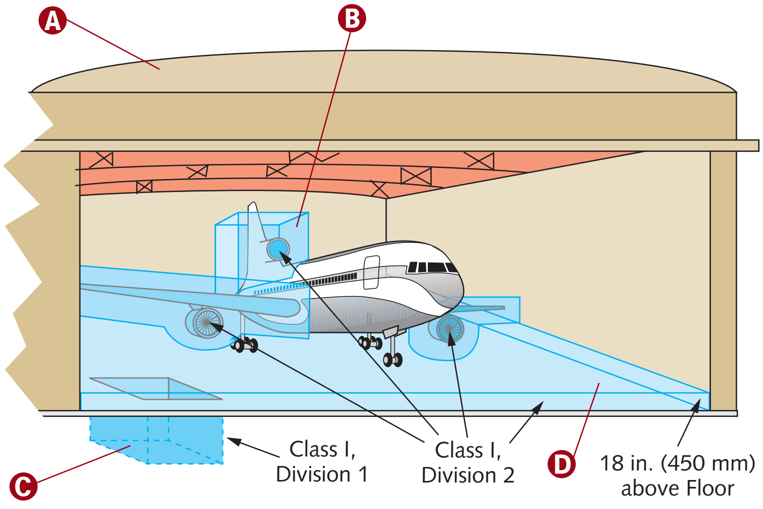
Portable utilization equipment and luminaires require flexible cord suitable for the type of service and identified for extra-hard usage. Such cords shall include a separate equipment grounding conductor »*513.10(E)(1)* and *(2)*«.

Adjacent areas in which flammable liquids or vapors are not likely to be released (stock rooms, electrical control rooms, etc.) shall be unclassified, provided such areas are adequately ventilated and effectively cut off from the hangar itself by walls or partitions »*513.3(D)*«.

Portable utilization equipment that can be, or is, used within a hangar shall be of a type suitable for use in Class I, Division 2 or Zone 2 locations »*513.10(E)(2)*«.

Seals shall be provided in accordance with 501.15 or 505.16, as applicable. Sealing requirements specified apply both to horizontal and vertical Class I location boundaries »*513.9*«.





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Aircraft Hangars *(continued)*

All metal raceways, the metal armor or metallic sheath on cables, and all non-current-carrying metal parts of fixed/portable electrical equipment, regardless of voltage, shall be grounded. Grounding in Class I locations shall comply with 501.30 or 505.30 for Zone 0, 1, and 2 locations »*513.16(A)*«.

A Article 513 applies to buildings/structures or parts thereof inside which aircraft (containing Class I liquids or Class II liquids whose temperatures exceed their flash points) are housed, stored, serviced, repaired, or altered. It does not apply to locations used exclusively for aircraft that do not now, nor have ever, contained fuel »*513.1*«.

B The area within 5 ft (1.5 m) horizontally from aircraft power plants or fuel tanks is a Class I, Division 2 or Zone 2 location extending upward from the floor to a level 5 ft (1.5 m) above the upper surface of wings and engine enclosures »*513.3(C)(1)*«.

C Any pit or depression below the hangar floor level is a Class I, Division 1 or Zone 1 location that extends up to floor level »*513.3(A)*«.

D The hangar's entire area, including any adjacent and communicating areas not suitably separated from the hangar, is designated as a Class I, Division 2 or Zone 2 location up to a level 18 in. (450 mm) above the floor »*513.3(B)*«.

Note

In locations above those described in 513.3, equipment less than 10 ft (3.0 m) above aircraft wings and engine enclosures, which may produce arcs, sparks, or particles of hot metal (such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, charging panels, generators, motors, or other equipment having make-or-break or sliding contacts), shall be of the totally enclosed type or by construction shall prevent the escape of sparks or hot metal particles »*513.7(C)*«.

Bulk Storage Plants

Sealing requirements apply to horizontal as well as vertical boundaries of the defined Class I locations. Buried raceways and cables under a defined Class I area are considered to be within a Class I, Division 1 or Zone 1 location »*515.9*«.

Underground wiring shall be enclosed in either threaded RMC or threaded steel IMC; if buried under at least 2 ft (600 mm) of cover, PVC conduit, RTRC conduit (or a listed cable) can be used. If PVC conduit or RTRC conduit is used, threaded metal conduit (either rigid or steel intermediate) shall be used for not less than the last 2 ft (600 mm) of the conduit run to the conduit point of emergence from the underground location or to the point of connection to an aboveground raceway. Cable, if used, shall also be enclosed in threaded metal conduit (either rigid or steel intermediate) from the point of lowest buried cable to the point of aboveground raceway connection »*515.8(A)*«.

Where PVC conduit, RTRC conduit, or cable with a nonmetallic sheath is used, include an equipment grounding conductor to provide electrical continuity of the raceway system and grounding of non-current-carrying metal parts »*515.8(C)*«.

Where gasoline or other volatile flammable liquids or liquefied flammable gases are dispensed at bulk stations, the appropriate provisions of Article 514 also apply unless modified by Article 515 »*515.10*«.

All metal raceways, the metal armor or metallic sheath on cables, and all non-current-carrying metal parts of fixed/portable electrical equipment, regardless of voltage, shall be grounded and bonded »*515.16*«.

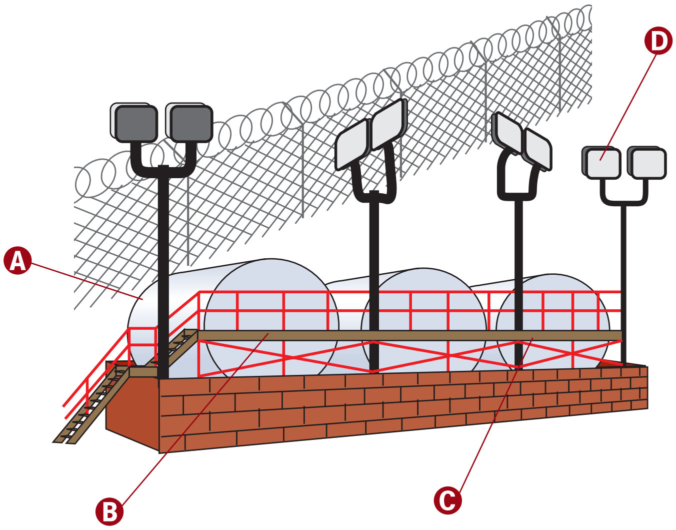
A Article 515 covers a property or portion of a property where flammable liquids are received by tank vessel, pipelines, tank car, or tank vehicle and are stored or blended in bulk for the purpose of distributing such liquids by tank vessel, pipeline, tank car, tank vehicle, portable tank, or container »*515.1*«.

B Apply Table 515.3 where Class I liquids are stored, handled, or dispensed. Table 515.3 is also used to delineate and classify bulk storage plants. The class location does not extend beyond any floor, wall, roof, or other solid partition that has no communicating openings »*515.3*«.

C All electrical wiring and equipment within the hazardous (classified) locations defined in 515.3 shall comply with the applicable requirements of Table 515.2 »*515.4*«.

Note

The referenced articles in Table 515.2 are applicable to bulk storage plants except as modified by Article 515.



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Bulk Storage Plants *(continued)*

D All fixed wiring above hazardous (classified) locations shall comply with 501.10(B) or 505.15(C). Fixed equipment that might produce arcs, sparks, or particles of hot metal (such as lamps and lampholders for fixed lighting, cutouts, switches, receptacles, motors, or other equipment having make-or-break or sliding contacts), shall either be of the totally enclosed type or otherwise be constructed to prevent the escape of sparks or hot metal particles. Portable luminaires or other utilization equipment and associated flexible cords shall comply with Part III of Article 501 or 505.17 for the class of location above which they are connected or used »*515.7(A), (B),* and *(C)*«. (See pages 366 through 368 for a list of approved wiring methods and sealing requirements.)

Spray Application, Dipping, Coating, and Printing Processes Using Flammable or Combustible Materials

Article 516 covers the regular or frequent application of flammable liquids, combustible liquids, and combustible powders by spray operations and the application of flammable liquids or combustible liquids at temperatures above their flashpoint by spraying, dipping, coating, printing, or other means »*516.1*«. Article 516 contains five parts: Part I General; Part II Open Containers; Part III Spray Application Processes; Part IV Spray Applications Operations in Membrane Enclosures; and Part V Printing, Dipping, and Coating Processes.

For open containers, supply containers, waste containers, spray gun cleaners, and solvent distillation units that contain Class I liquids that are located in ventilated areas, area classification shall be in accordance with the requirements in 516.4.

For spray application processes, the area classification is based on quantities of flammable vapors, combustible mists, residues, dusts, or deposits that are present or might be present in quantities sufficient to produce ignitable or explosive mixtures with air »*516.5*«. (See 516.5 for requirements pertaining to spray application processes.)

All metal raceways, the metal armor or metallic sheath on cables, and all non-current-carrying metal parts of fixed/portable electrical equipment, regardless of voltage, shall be grounded and bonded. Grounding and bonding shall comply with 501.30, 502.30, or 505.30, as applicable »*516.16*«.

A Classification for printing, dipping, and coating processes is based on quantities of flammable vapors, combustible mists, residues, dusts, or deposits that are present or might be present in quantities sufficient to produce ignitable or explosive mixtures with air. Electrical wiring and electrical utilization equipment located adjacent to open processes shall comply with the requirements in 516.29 through 516.40 »*516.29*«.

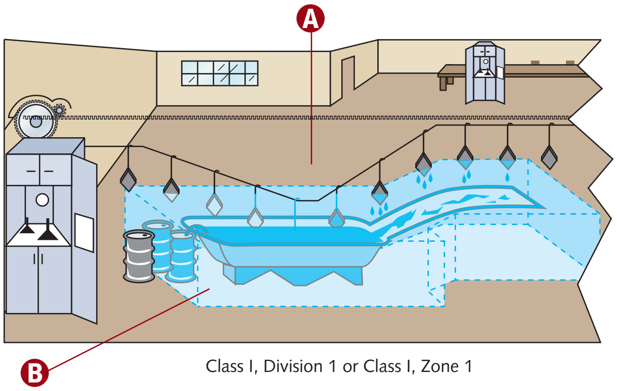
B Electrical wiring and electrical utilization equipment located within 5 ft (1525 mm) of a vapor source shall be suitable for Class I, Division 1 or Class I, Zone 1 locations. The space inside a dip tank, ink fountain, ink reservoir, or ink tank shall be classified as Class I, Division 1 or Class I, Zone 0, whichever is applicable »*516.29(2)*«.

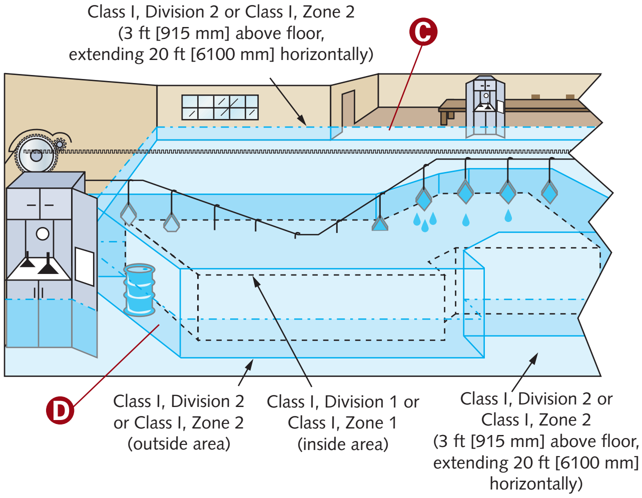
C The space 3 ft (915 mm) above the floor and extending 20 ft (6100 mm) horizontally in all directions from the Class I, Division 1 or Class I, Zone 1 location shall be classified as Class I, Division 2 or Class I, Zone 2, and electrical wiring and electrical utilization equipment located within this space shall be suitable for Class I, Division 2 or Class I, Zone 2 locations, whichever is applicable »*516.29(4)*«.

D Electrical wiring and electrical utilization equipment located within 3 ft (915 mm) of the Class I, Division 1 or Class I, Zone 1 location shall be suitable for Class I, Division 2 or Class I, Zone 2 locations, whichever is applicable »*516.29(3)*«.

Note

Wiring and equipment above Class I and Class II locations must comply with 516.7 specifications.




Class I, Division 2 or Class I, Zone 2 (3 ft [915 mm] above floor, extending 20 ft [6100 mm] horizontally)
C
D
Class I, Division 2 or Class I, Zone 2 (outside area)
Class I, Division 1 or Class I, Zone 1 (inside area)
Class I, Division 2 or Class I, Zone 2 (3 ft [915 mm] above floor, extending 20 ft [6100 mm] horizontally)

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Class II Locations

Class II, Division 1 Locations

In addition to the requirements found in Article 500, wiring and equipment in Class II locations shall meet Article 502's provisions.

***Dust-ignitionproof* means equipment enclosed in a manner that excludes dust, and, where installed and protected in accordance with this *Code*, which does not permit arcs, sparks, or heat otherwise generated or liberated inside the enclosure to ignite exterior accumulations or atmospheric suspensions of a specified dust on or near the enclosure »*Article 100*«.**

The temperature marking for Class II locations, per 500.8(C), shall be less than the ignition temperature of the specific dust or metal fiber/flying to be encountered. For organic dusts that might dehydrate or carbonize, the temperature marking shall not exceed the lower of either the ignition temperature or 165°C (329°F) »*500.8(D)(2)*«.

The type of equipment and wiring defined as explosionproof (in Article 100) is not required and shall not be acceptable for Class II locations unless also identified for such locations »*502.5*«.

In Class II, Division 1 locations, transformers and capacitors containing burnable liquid shall be installed only in vaults compliant with 450.41 through 450.48, in addition to all the following stipulations: (1) openings (doors, etc.) communicating with the Division 1 locations shall have self-closing fire doors on both sides of the wall, carefully fitted and having suitable seals (such as weather stripping) to minimize the entrance of dust into the vault; (2) vent openings and ducts shall communicate only with the outside air; and (3) suitable pressure-relief openings to the outside air shall be provided »*502.100(A)(1)*«. Subsequently, transformers and capacitors not containing burnable liquids shall either be installed in vaults complying with 450.41 through 450.48, or be identified as a complete assembly, including terminal connections »*502.100(A)(2)*«.

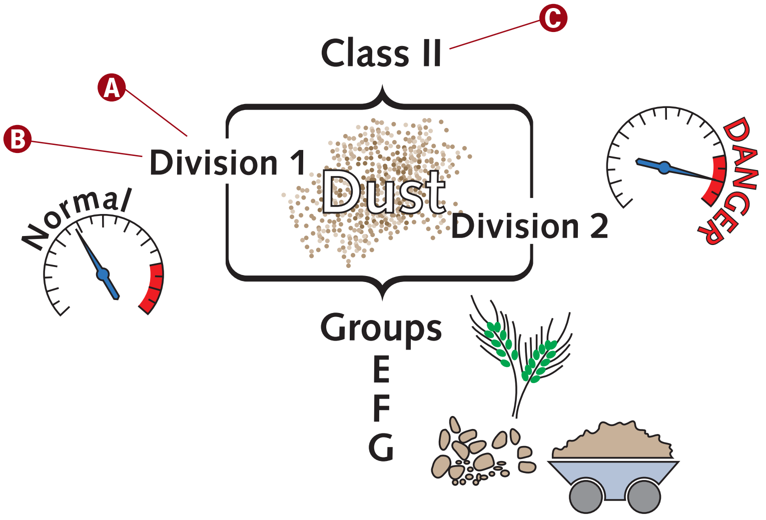
No transformer or capacitor shall be installed in a Class II, Division 1, Group E location »*502.100(A)(3)*«.

Equipment listed and marked in accordance with 506.9(C)(2) for Zone 20 locations shall be permitted in Class II, Division 1 locations for the same dust atmosphere, and with a suitable temperature class »*502.6*«.

A A Class II, Division 1 location is an area (1) in which combustible dust is airborne under normal operating conditions in quantities sufficient to produce explosive or ignitible mixtures; (2) where mechanical failure or abnormal operation of machinery/equipment might not only produce such explosive or ignitible mixtures, but also provide an ignition source through simultaneous failure of electric equipment, operation of protection devices, or by other causes; or (3) in which Group E combustible dusts may exist in hazardous quantities »*500.5(C)(1)*«.

B Because dusts containing magnesium or aluminum are particularly hazardous, extreme precautions are necessary to avoid ignition and explosion »*500.5(C)(1) Informational Note*«.

C Class II locations are hazardous because of the presence of combustible dust »*500.5(C)*«.



Note

Bonding and grounding must comply with 502.30(A) and (B) provisions.

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Class II, Division 2 Locations

In Class II, Division 2 locations, transformers and capacitors containing burnable liquid shall be installed within vaults compliant with 450.41 through 450.48 »*502.100(B)(1)*«.

Askarel-containing transformers, rated in excess of 25 kVA, shall have (1) pressure-relief vents; (2) a means for absorbing any gases generated by arcing inside the case, or chimney/flue-connected pressure-relief vents that shall carry such gases outside the building; and (3) at least 6 in. (150 mm) of airspace between the transformer case and any adjacent combustible material »*502.100(B)(2)*«.

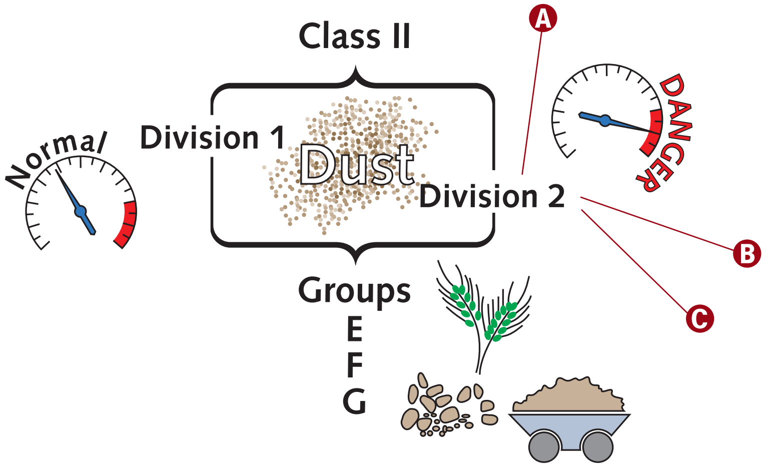
Dry-type transformers, operating at not over 600 volts, nominal, shall either be installed in vaults or shall have their windings and terminal connections enclosed in tight metal housings without ventilation or other openings »*502.100(B)(3)*«.

Equipment listed and marked in accordance with 506.9(C)(2) for Zone 20, 21, or 22 locations shall be permitted in Class II, Division 2 locations for the same dust atmosphere and with a suitable temperature class »*502.6*«.

Ⓐ A Class II, Division 2 location is an area (1) where combustible dust due to abnormal operations may be present in the air in quantities sufficient to produce explosive or ignitible mixtures; (2) where combustible dust accumulations typically do not interfere with normal operation of electrical equipment or other apparatus, but may become airborne as a result of infrequent malfunctioning of processing/handling equipment; and (3) where combustible dust accumulations on, in, or near electrical equipment may be sufficient to interfere with safe heat dissipation from said equipment, or may be ignited by abnormal operation or failure of electrical equipment »*500.5(C)(2)*«.

Ⓑ The quantity of combustible dust that may be present and the adequacy of dust removal systems are factors that merit consideration in determining the classification and may result in an unclassified area »*500.5(C)(2) Informational Note No. 1*«.

Ⓒ Where the handling of substances such as seed produces low quantities of dust, the amount of dust deposited may not warrant classification »*500.5(C)(2) Informational Note No. 2*«.



Note
Bonding and grounding must comply with 502.30(A) and (B) provisions.

Wiring Methods—Class II, Divisions 1 and 2

Approved wiring methods in Class II, Division 1 locations include threaded RMC, threaded steel IMC, or Type MI cable with termination fittings listed for the location. Type MI cable shall be installed and supported in a manner to avoid tensile stress at the termination fittings »*502.10(A)(1)(1) and (2)*«. In restricted industrial establishments Class II, Division 1–listed Type MC-HL cable with a gas/vaportight continuous corrugated metallic sheath, an overall jacket of suitable polymeric material, separate equipment grounding conductors (per 250.122), and termination fittings listed for the application are permitted »*502.10(A)(1)(3)*«.

Class II, Division 1 fittings and boxes shall be provided with threaded bosses for conduit connections or cable terminations and shall be dusttight. Fittings and boxes containing taps, joints, or terminal connections or those that are used in Group E locations shall be identified for Class II locations »*502.10(A)(3)*«.

For flexible connections, use only (1) dusttight flexible connectors; (2) LFMC with listed fittings; (3) LFNC with listed fittings; (4) interlocked armor Type MC cable having an overall jacket of suitable polymeric material and provided with termination fittings listed for Class II,

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Wiring Methods—Class II, Divisions 1 and 2 *(continued)*

Division 1 locations; (5) flexible cord listed for extra-hard usage and terminated with listed dusttight cord connectors. Any flexible cords used shall comply with 502.140; (6) for elevator use, an identified elevator cable of Type EO, ETP, or ETT, shown under the "use" column in Table 400.4 for "hazardous (classified) locations" and terminated with listed dusttight fittings; (7) Type TC-ER-HL cable in restricted industrial establishments for circuits not over 600 volts with listed fittings and where the cable is not subject to physical damage; or (8) Type P cable in restricted industrial establishments if the cable has a metal braid armor, has an overall jacket, and is terminated with listed fittings »*502.10(A)(2)* and *(B)(2)*«.

Sealing fittings shall be accessible »*502.15*«.

Unless an exception is met, approved wiring methods in Class II, Division 2 locations include (1) all wiring methods permitted in 502.10(A); (2) RMC or IMC; (3) dusttight wireways or EMT with listed compression connectors; (4) Type MC, MV, TC, or TC-ER cable with listed termination fittings; (5) Type PLTC and Type PLTC-ER cable used in Class 2 or Class 3 circuits, including installation in cable tray systems (the cable shall be terminated with listed fittings); (6) Type ITC and Type ITC-ER cable as permitted in 335.4 and terminated with listed fittings; (7) where metallic conduit does not provide sufficient corrosion resistance, reinforced thermosetting resin conduit (RTRC) factory elbows, and associated fittings, all marked with suffix-XW, and Schedule 80 PVC Conduit, factory elbows, and associated fittings when installed in restricted industrial establishments; (8) Types OFNP, OFCP, OFNR, OFCR, OFNG, OFN, or OFC optical fiber cables; (9) cablebus or (10) Type P cable in restricted industrial establishments if the cable has an outer jacket and is terminated with listed fittings and installed in accordance with 337.10 »*502.10(B)(1)*«.

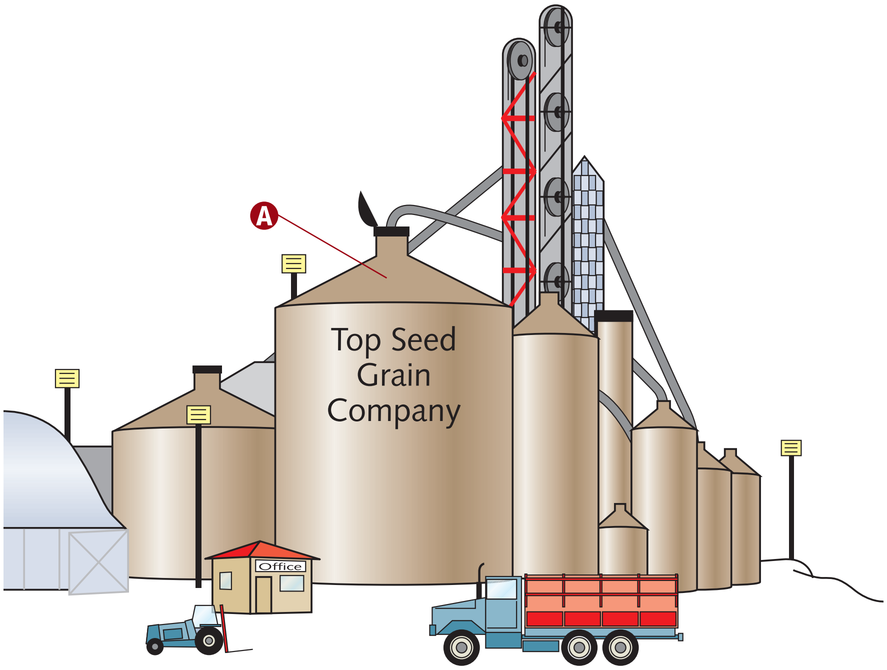
All Class II, Division 2 boxes and fittings shall be dusttight »*502.10(B)(4)*«.

In Class II, Division 1 and 2 locations, where a raceway provides communication between an enclosure that is required to be dust-ignitionproof and one that is not, suitable means shall prevent the entrance of dust into the dust-ignitionproof enclosure via the raceway. The following means are permitted: (1) a permanent and effective seal; (2) a horizontal raceway at least 10 ft (3.05 m) long; (3) a vertical raceway not less than 5 ft (1.5 m) long that extends downward from the dust-ignitionproof enclosure; (4) a raceway installed in a manner equivalent to (2) or (3) that extends only horizontally and downward from the dust-ignitionproof enclosures or (5) electrical sealing putty »*502.15*«.

Seals are not required where a raceway provides communication between an enclosure that is required to be dust-ignitionproof and an enclosure in an unclassified location »*502.15*«.

In Class II, Division 1 and 2 locations, explosionproof seals are not required »*502.15*«.

A Class II locations are hazardous because of the presence of combustible dust »*500.5(C)*«.



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Class III Locations

Class III, Division 1 Locations

In addition to Article 500 requirements, wiring and equipment in locations designated Class III must be installed in accordance with provisions in Article 503.

Class III located equipment shall be able to function at full rating without developing surface temperatures high enough to cause excessive dehydration or gradual carbonization of accumulated fibers or flyings »*503.5*«.

Transformers and capacitors in Class III, Division 1 locations shall comply with 502.100(B) »*503.100*«.

Equipment listed and marked in accordance with 506.9(C)(2) for Zone 20 locations and with a temperature marking in accordance with 500.8(D)(3) shall be permitted in Class III, Division 1 locations »*503.6*«.

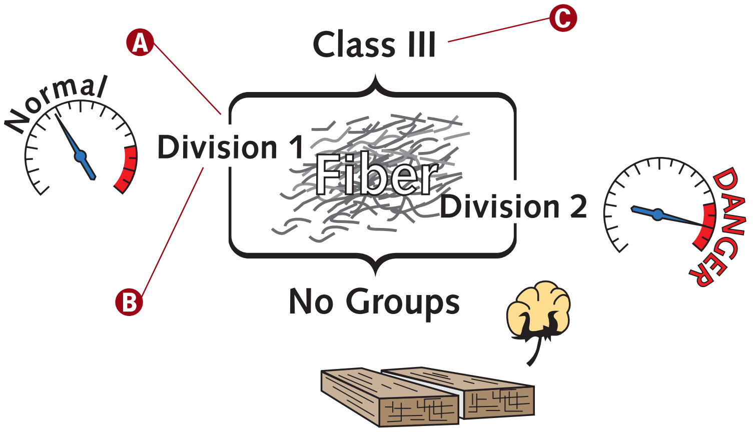
Ⓐ A Class III, Division 1 location is an area where combustible or ignitible fibers/flyings are handled, manufactured, or used »*500.5(D)(1)*«.

Ⓑ Ignitible fibers/flyings include rayon, cotton (including cotton linters and cotton waste), sisal or henequen, istle, jute, hemp, tow, cocoa fiber, oakum, baled waste kapok, Spanish moss, excelsior, and other materials of similar nature »*500.5(D)(1) Informational Note No. 2*«.

Ⓒ Class III locations are those that are hazardous because of the presence of combustible or ignitible fibers or flyings, such as rayon or cotton »*500.5(D)*«.

Note

Bonding and grounding shall comply with 503.30(A) and (B) provisions.



Class III, Division 2 Locations

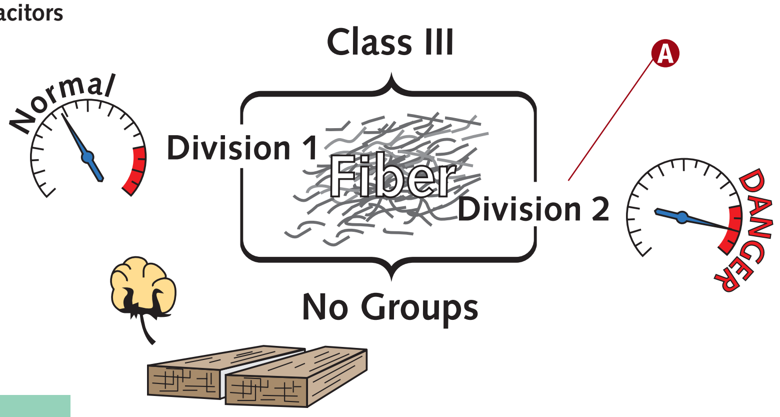
In Class III, Division 2 locations, transformers and capacitors shall comply with 502.100(B) »*503.100*«.

Equipment listed and marked in accordance with 506.9(C)(2) for Zone 20, 21, or 22 locations and with a temperature marking in accordance with 500.8(D)(3) shall be permitted in Class III, Division 2 locations »*503.6*«.

Ⓐ A Class III, Division 2 location is an area in which combustible or ignitible fibers/flyings are stored or handled other than in the manufacturing process »*500.5(D)(2)*«.

Note

Bonding and grounding must comply with 503.30(A) and (B) provisions.



Wiring Methods—Class III, Division 1

In Class III, Division 1 locations, the following wiring methods are permitted: (1) RMC, PVC, RTRC, IMC, EMT, dusttight wireways, or Type MC or MI cable with listed termination fitting; (2) Type PLTC and Type PLTC-ER cable used in Class 2 and Class 3 circuits including installation in cable tray systems (the cable shall be terminated with listed fittings); (3) Type ITC and Type ITC-ER cable as permitted in 335.4 and terminated with listed fittings; (4) Type MV, TC, or TC-ER cable including installation in cable tray systems (cables must be terminated with listed fittings); (5) cablebus; or (6) Type P cable in restricted industrial establishments when installed in accordance with Part II of Article 337 »*503.10(A)*«.

All Class III, Division 1 boxes and fittings shall be dusttight »*503.10(A)(2)*«.

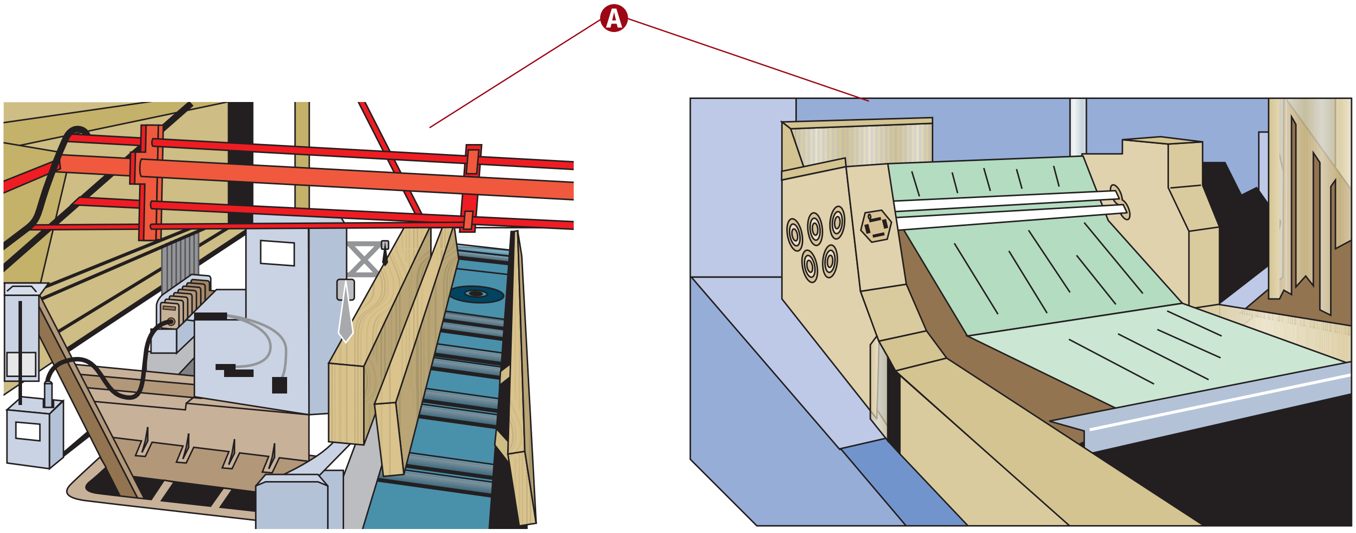
Where necessary to employ flexible connections, one or more of the following shall be permitted: (1) dusttight flexible connectors, (2) liquidtight flexible metal conduit with listed fittings, (3) liquidtight flexible nonmetallic conduit with listed fittings, (4) interlocked armor Type MC cable having an overall jacket of suitable polymeric material and installed with listed dusttight termination fittings, (5) flexible cord in compliance with 503.140 (6) for elevator use, an identified elevator cable of Type EO, ETP, or ETT, shown under the "use" column in Table 400.4 for "hazardous (classified) locations" and terminated with listed dusttight fittings; and (7) Type P cable in restricted industrial establishments if the cable has a metal braid armor, has an overall jacket, is terminated with listed fittings, and is installed in accordance with Part II of Article 337 »*503.10(A)(3)*«. For bonding requirements where flexible conduit is used, see 503.30(B).

Class III, Division 1 and 2 switches, circuit breakers, motor controllers, and fuses (including push buttons, relays, and similar devices), shall have dusttight enclosures »*503.115*«.

Class III, Division 1 and 2 flexible cords shall comply with the following: (1) be of a type listed for extra-hard usage; (2) contain, in addition to the conductors of the circuit, a 400.23 compliant equipment grounding conductor; (3) be supported by clamps or other suitable means so that there will be no tension on the terminal connections; and (4) be terminated with a listed dusttight cord and connector »*503.140*«.

Class III, Division 1 and 2 receptacles and attachment plugs shall (1) be of the grounding type; (2) be designed to minimize the accumulation (or entry) of fibers/flyings; and (3) prevent the escape of sparks or molten particles »*503.145*«. If, in the judgment of the AHJ, only moderate accumulations of lint ignitible fibers/flyings are likely to collect in the vicinity of a receptacle, and where such receptacle is readily accessible for routine cleaning, general-purpose grounding-type receptacles (mounted to minimize the entry of fibers/flyings) are permitted »*503.145 Exception*«.

Ⓐ Such locations usually include some parts of rayon, cotton, and other textile mills; combustible fibers/flyings manufacturing and processing plants; cotton gins and cotton-seed mills; flax-processing plants; clothing manufacturing plants; woodworking plants; and establishments and industries involving similar hazardous processes or conditions »*500.5(D)(1) Informational Note No. 1*«.



Woodworking Plant

Textile Production Equipment

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Wiring Methods—Class III, Division 2

Unless the requirements in 503.10(B)(2) are met, Class III, Division 2 location wiring methods shall comply with 503.10(A) »*503.10(B)*«.

All Class III, Division 2 boxes and fittings shall be dusttight »*503.10(A)(2)*«.

Class III, Division 1 and 2 pendant luminaires shall be suspended by stems of threaded RMC, threaded IMC, threaded metal tubing of equivalent thickness, or by chains with approved fittings. Stems longer than 12 in. (300 mm) shall be permanently and effectively braced against lateral displacement at a level no more than 12 in. (300 mm) above the lower end of the stem, or flexibility in the form of an approved fitting or a flexible connector shall be provided no more than 12 in. (300 mm) from the point of attachment to the supporting box or fitting »*503.130(C)*«.

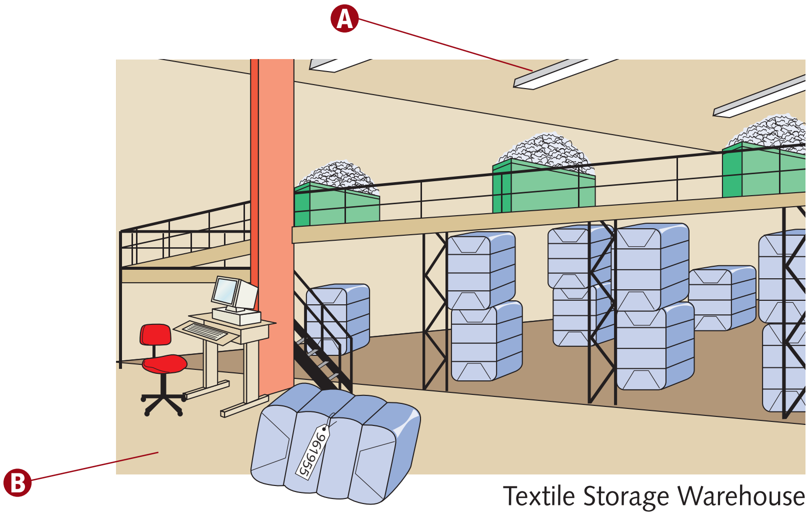
Class III, Division 1 and 2 portable lighting equipment shall have both handles and substantial guards. Lampholders shall be of the unswitched type, incapable of receiving attachment plugs. There shall be no exposed current-carrying metal parts, and all exposed non-current-carrying metal parts shall be grounded. In all other respects, portable lighting equipment shall comply with 503.130(A) »*503.130(D)*«.

A Class III, Division 1 and 2 luminaires for fixed lighting shall provide enclosures for lamps and lampholders designed to minimize entrance of fibers/flyings and to prevent the escape of sparks, burning material, or hot metal. Each luminaire shall be clearly marked to show the maximum permitted lamp wattage without exceeding an exposed surface temperature of 165°C (329°F) under normal conditions of use »*503.130(A)*«.

B A Class III, Division 2 location is a location in which combustible or ignitible fibers/flyings are stored or handled other than in the process of manufacture »*500.5(D)(2)*«.

Note

Class III, Division 1 and 2 luminaires subject to physical damage shall be protected by a suitable guard »***503.130(B)***«.



Textile Storage Warehouse

Summary

- Hazardous locations are divided into three classifications (Class I, II, and III); each class is subdivided into two categories (Division 1 and 2).
- While Article 500 covers general requirements for all classes, Articles 501, 502, and 503 provide specific provisions for each class individually.
- Class I locations are those in which flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.
- Class II locations are hazardous due to the presence of combustible dust.
- Class III locations are those that are hazardous because of the presence of combustible or ignitible fibers or flyings, such as rayon or cotton.
- Under typical operating conditions, Division 1 locations contain ignitible or combustible elements (gases, dust, fibers, etc.) in quantities sufficient to produce explosive (or ignitible) mixtures.
- Locations where ordinarily present quantities of combustible or ignitible elements (gases, dust, fibers, etc.) in the air are insufficient to produce explosive (or ignitible) mixtures are classified as Division 2.
- Article 511 occupancies include those used for service and repair of self-propelled vehicles (including, but not limited to, passenger automobiles, buses, trucks, and tractors) that use volatile flammable liquids for fuel or power.
- Article 513 applies to buildings/structures or parts thereof inside which aircraft (containing Class I or II liquids whose temperatures exceed their flash points) are housed, stored, serviced, repaired, or altered.
- Motor fuel dispensing facility requirements are in Article 514.
- Article 515 provisions address bulk storage plants.
- The regular (or frequent) spray application of flammable liquids, combustible liquids, and combustible powders, as well as the application of flammable/combustible liquids at temperatures above their flashpoint, by spraying, dipping, coating, printing, or other means, are covered by Article 516.

Unit 15 Competency Test

***NEC*® Reference**	**Answer**	
___________	___________	1. In aircraft hangars, any pit or depression below the level of the hangar floor shall be classified as a ___________ location that shall extend up to said floor level.
___________	___________	2. Regardless of the classification of the location in which it is installed, equipment that depends on a single compression seal, diaphragm, or tube to prevent flammable or combustible fluids from entering the equipment, shall be identified for a ___________ location.
___________	___________	3. A ___________ location is a location in which volatile flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are handled, processed, or used, but in which the liquids, vapors, or gases will normally be confined within closed containers or closed systems from which they can escape only in case of accidental rupture or breakdown of such containers or systems or in case of abnormal operation of equipment.
___________	___________	4. All cut ends of rigid metal conduit (RMC) shall be reamed or otherwise finished to remove rough edges. Where conduit is threaded in the field, a standard cutting die with a ___________ in. taper per foot shall be used.
___________	___________	5. In bulk storage plants, aboveground (fixed roof) tank vents shall be classified as ___________ within 5 ft (1.5 m) of the open end of the vent, extending in all directions.
___________	___________	6. In Class I, Division 1 locations, NPT threaded entries into explosionproof equipment shall be made up with at least ___________ threads fully engaged.
___________	___________	7. In Class II, Division 1 locations, boxes and fittings shall be provided with ___________ for connection to conduit or cable terminations, and shall be dusttight.
___________	___________	8. A 2-in. threaded RMC is terminating into a 2-in. sealing fitting. The minimum thickness of the sealing compound shall be ___________ in.
___________	___________	9. In aircraft hangars, the area within ___________ ft horizontally from aircraft power plants or aircraft fuel tanks shall be classified as a Class I, Division 2 or Zone 2 location that shall extend upward from the floor to a level ___________ ft above the upper surface of wings and engine enclosures.
___________	___________	10. ___________ is defined as equipment enclosed in a manner that will exclude dusts and does not permit arcs, sparks, or heat otherwise generated or liberated inside of the enclosure to cause ignition of exterior accumulations or atmospheric suspensions of a specified dust on or in the vicinity of the enclosure.
___________	___________	11. Class I locations are those in which ___________ are or may be present in the air in quantities sufficient to produce explosive or ignitible mixtures.
___________	___________	12. In commercial garages, lamps and lampholders for fixed lighting that is located over lanes through which vehicles are commonly driven shall be located no less than ___________ ft above the floor level.
___________	___________	13. A ___________ location is a location in which ignitible fibers/flyings are handled, manufactured, or used.
___________	___________	14. ___________, ___________, ___________, ___________, and ___________ are five acceptable hazardous (classified) location protection techniques for electrical and electronic equipment.
___________	___________	15. A(n) ___________ is defined as a circuit other than field wiring in which any arc or thermal effect produced under intended operating conditions of the equipment is not capable, under specified test conditions, of igniting the flammable gas–, vapor–, or dust–air mixture.

***NEC*® Reference** **Answer**

____________ ____________ 16. In each conduit run passing from a Class I, Division 2 location into an unclassified area, the sealing fitting shall be located within ____________ ft of the boundary.

____________ ____________ 17. For open printing, dipping, and coating processes, electrical wiring and electrical utilization equipment located within ____________ feet of a vapor source shall be suitable for Class I, Division 1 or Class I, Zone 1 locations.

____________ ____________ 18. In Class III, Division 2 locations, transformers and capacitors shall comply with *NEC* Section ____________.

____________ ____________ 19. An outdoor gasoline dispensing device is considered to be a Class I, Division 2 location up to ____________ in. above grade level, extending ____________ ft horizontally in all directions from dispenser enclosure.

____________ ____________ 20. In bulk storage plants, the space between ____________ ft and ____________ ft from the open end of an aboveground (fixed roof) tank vent, extending in all directions, is a Class I, Division 2 or Zone 2 location.

____________ ____________ 21. A(n) ____________ enclosure is constructed so that dust will not enter under specified test conditions.

____________ ____________ 22. For open printing, dipping, and coating processes, the space ____________ ft above the floor and extending ____________ ft horizontally in all directions from the Class I, Division 1 or Class I, Zone 1 location shall be classified as Class I, Division 2 or Class I, Zone 2, and electrical wiring and electrical utilization equipment located within this space shall be suitable for Class I, Division 2 or Class I, Zone 2 locations, whichever is applicable.

____________ ____________ 23. Aircraft energizers shall be designed and mounted so that all electric equipment and fixed wiring will be at least ____________ in. above floor level.

____________ ____________ 24. A ____________ location is a location in which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitible mixtures.

____________ ____________ 25. For each major repair garage floor, the entire area up to a level of ____________ in. above the floor shall be considered to be a Class I, Division 2 location if ventilation is not provided.

____________ ____________ 26. A ½-in. threaded steel IMC is terminating into a ½-in. sealing fitting. The minimum thickness of the sealing compound shall be ____________ in.

____________ ____________ 27. The entire area of an aircraft hangar, including any adjacent and communicating areas not suitably separated from the hangar, shall be classified as a Class I, Division 2 or Zone 2 location up to a level ____________ in. above the floor.

____________ ____________ 28. Fuel dispensing systems shall be provided with one or more clearly identified emergency shutoff devices or electrical disconnects. Such devices or disconnects shall be installed in approved locations but not less than ____________ ft or more than ____________ ft from the fuel dispensing devices that they serve.

____________ ____________ 29. Combustible dust is defined as solid particles that are ____________ micrometers or smaller (i.e., material passing a U.S. No. 35 Standard Sieve as defined in ASTM E11-17, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves) that can form an explosible mixture when suspended in air at standard atmospheric pressure and temperature.

____________ ____________ 30. Equipment installed in Class III locations shall be able to function at full rating without developing ____________ high enough to cause excessive dehydration or gradual carbonization of accumulated fibers/flyings.

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Unit 16

Section Five: Special Occupancies, Areas, and Equipment

Health Care

Objectives

After studying this unit, the student should be able to:

- demonstrate understanding of health care facility terminology.
- summarize general as well as specific hospital, nursing home, and limited-care facility requirements.
- define an ambulatory health care occupancy.
- clarify what area constitutes the patient care vicinity.
- recall grounding and bonding requirements in health care facilities.
- define wet procedure locations.
- explain Category 2 and Category 1 space branch-circuit and receptacle requirements.
- summarize receptacle/receptacle cover tamper-resistance requirements for patient rooms, bathrooms, playrooms, and activity rooms of pediatric units.
- identify the three types of essential electrical systems for hospitals; life safety branch, critical branch, and equipment branch.
- recall the receptacle requirements for operating rooms.
- clarify the required nursing home and limited-care facility branches (life safety and equipment).
- explain in detail hazardous (classified) anesthetizing location requirements.
- summarize diagnostic imaging and treatment installation provisions, including both fixed (stationary) and mobile equipment.

Introduction

Health care facilities, by definition, are buildings or portions of buildings, or mobile enclosures in which human medical, dental, psychiatric, nursing, obstetrical, or surgical care are provided. Electrical installation criteria and wiring methods for health care facilities are far more specialized than for a standard commercial or industrial project. Article 517 of the *NEC®* governs electrical installations within health care facilities. Applicable requirements of *NEC* Chapters 1 through 4 must be met, unless specifically modified by Article 517. The provisions of Article 517, Parts II and III, apply not only to single-function buildings, but are also intended for individual application to their respective forms of occupancy within a multifunction structure (for example, 517.10(A) requirements must be met by a doctor's examining room situated within a limited-care facility). As with any specialized endeavor, a working knowledge of the pertinent terminology is highly recommended. The definitions of these and other related terms can be found in Article 100. Article 517, Part II *(Wiring and Protection)* covers patient care spaces throughout the spectrum of health care facilities. *Essential Electrical Systems* (Part III) outlines electrical system requirements for specific occupancies, that is, hospitals, nursing homes, etc. *Inhalation Anesthetizing Location* provisions are presented in Part IV of Article 517. Part V covers *Diagnostic Imaging and Treatment Equipment.* In no way is Part V to be construed as specifying safeguards against possible radiation or magnetic fields. As for *Communications, Signaling Systems, Data Systems, Fire Alarm Systems, and Systems Less than 120 Volts, Nominal,* see Part VI for particular provisions. And finally, Article 517, Part VII applies to the installation of *Isolated Power Systems* that consist of an isolating transformer (or equivalent) and a line isolation monitor with its ungrounded circuit conductors. All in all, Article 517 and the explanations found in this unit offer a reasonably complete picture of health care facility electrical system installations.

General

Nursing Home and Limited-Care Facility

Requirements in 517.40(C) through 517.44 do not apply to freestanding buildings used as nursing homes and limited-care facilities, provided that:

(1) Admitting and discharge policies are maintained that preclude providing care to any patient (or resident) who might need to be sustained by electrical life-support equipment.

(2) No surgical treatment requiring general anesthesia is offered.

(3) Automatic battery-operated systems or equipment shall be effective for a minimum of 1½ hours and otherwise in accordance with 700.12. Such a system shall capably supply lighting for exit lights, exit corridors, stairways, nursing stations, medical preparation areas, boiler rooms, and communications areas, as well as power to operate all alarm systems »*517.40(A) Exception*«.

Nursing homes and limited-care facilities that are contiguous with or adjacent to a hospital can have essential electrical systems supplied by the hospital »*517.40(C)*«.

Ⓐ **Nursing home:** A building (or part thereof) used for 24-hour housing and nursing care of four or more persons who, because of mental or physical incapacity, may be unable to safely provide for their own needs without assistance »*Article 100*«.

Ⓑ Nursing homes and limited-care facilities are included in the term **health care facilities.**

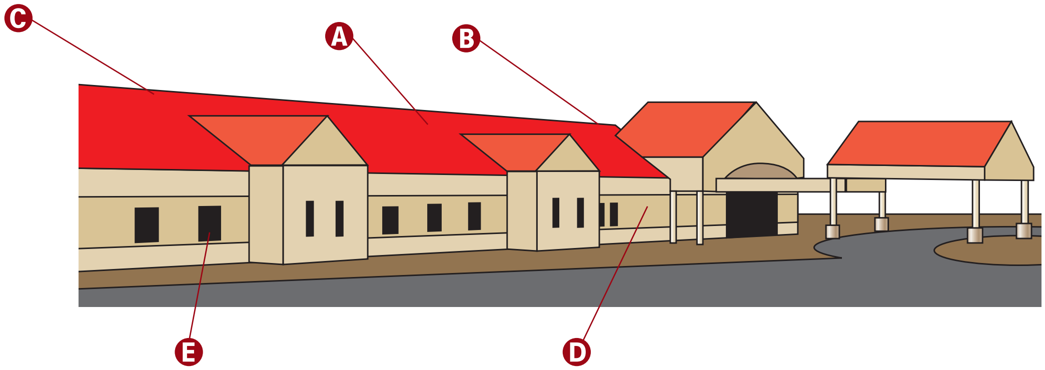
Ⓒ **Limited-care facility:** A building (or part thereof) used for 24-hour housing of four or more persons incapable of self-preservation because of age; physical limitation, whether due to accident or illness; or limitations, such as intellectual disability/developmental disability, mental illness, or chemical dependency »*Article 100*«.

Ⓓ The requirements of 517.40(C) through 517.44, shall apply to Category 2 spaces »*517.40(A)*«.

Ⓔ Article 517, Part II (Wiring and Protection) requirements shall not apply to areas of nursing homes and limited-care facilities wired in accordance with Chapters 1 through 4 of the *NEC* where these areas are used exclusively as patient sleeping rooms »*517.10(B)(2)*«.

Note

For those nursing home and limited-care facilities that admit patients who need to be sustained by electrical life-support equipment, the essential electrical system from the source to the portion of the facility where such patients are treated shall comply with the requirements of 517.29 through 517.35 »***517.40(B)***«.



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Hospital

The provisions of Article 517 shall apply to electrical construction and installation criteria in health care facilities that provide services to human beings »*517.1*«.

Article 517 specifies the installation criteria and wiring methods that minimize electrical hazards by maintaining adequately low-potential differences between exposed conductive surfaces that are likely to become energized and are subject to patient contact »*517.1*«.

Psychiatric hospital: A building used exclusively for 24-hour psychiatric care, with at least four inpatients »*Article 100*«.

Parts II and III requirements apply not only to single-function buildings, but also to their respective forms of occupancy within a multifunction building (for example, a doctor's examining room located within a limited-care facility shall meet 517.10(A) provisions) »*517.1*«.

A **Hospital:** A building (or part thereof) used for 24-hour medical, psychiatric, obstetrical, or surgical care of four or more inpatients »*Article 100*«.

B **Health care facilities:** Buildings, portions of buildings, or mobile enclosures in which human medical, dental, psychiatric, nursing, obstetrical, or surgical care is provided »*Article 100*«. Examples of health care facilities include, but are not limited to, hospitals, nursing homes, limited care facilities, clinics, medical and dental offices, and ambulatory care centers, whether permanent or movable »*Article 100 Health Care Facilities, Informational Note*«.

C **Patient bed location:** The location of a patient sleeping bed or the bed (or procedure table) of a Category 1 space »*Article 100*«.

D Article 517, Part II applies to patient care space of all health care facilities »*517.10(A)*«.

E **Patient care space:** Any space of a health care facility wherein patients are intended to be examined or treated »*Article 100*«. The four categories of patient care space are: Category 3 Space, Category 2 Space, Category 1 Space, and Category 4 Space.

F **Category 1 Space:** Space in which failure of equipment or a system is likely to cause major injury or death of patients, staff, or visitors »*Article 100 Category 1 Space under Patient Care Space*«.

Informational Note: Category 1 spaces, formerly known as critical care rooms, are typically where patients are intended to be subjected to invasive procedures and connected to line-operated, patient care-related appliances. Examples include, but are not limited to, special care patient rooms used for critical care, intensive care, and special care treatment rooms such as angiography laboratories, cardiac catheterization laboratories, delivery rooms, operating rooms, post-anesthesia care units, trauma rooms, and other similar rooms.

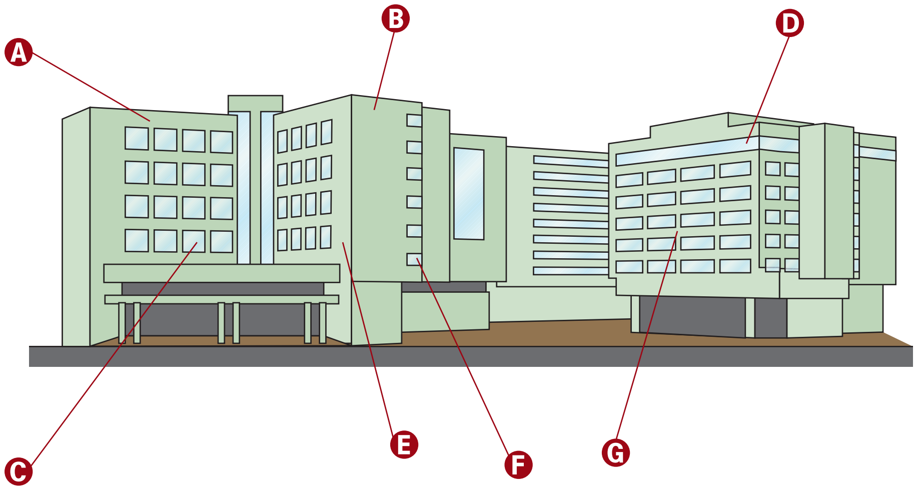
G **Category 2 Space:** Space in which failure of equipment or a system is likely to cause minor injury to patients, staff, or visitors »*Article 100 Category 2 Space under Patient Care Space*«.

Informational Note: Category 2 spaces were formerly known as general care rooms. Examples include, but are not limited to, inpatient bedrooms, dialysis rooms, in vitro fertilization rooms, procedural rooms, and similar rooms.

Note

Article 517, Part II does not apply to the following: (1) business offices, corridors, waiting rooms, and the like in clinics, medical and dental offices, and outpatient facilities; (2) areas of nursing homes and limited-care facilities wired according to Chapters 1 through 4 of the *NEC*, where these areas are used exclusively as patient sleeping rooms; and (3) areas used exclusively for intramuscular injections (immunizations), psychiatry and psychotherapy, alternative medicine, optometry, and pharmacy services not contiguous to health care facilities »*517.10(B)*«.

See Article 100 for definitions pertaining to health care facilities.



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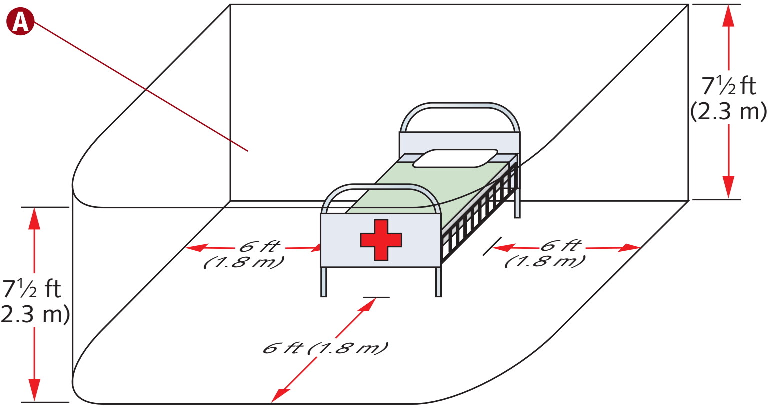
Patient Care Vicinity

Ⓐ **Patient care vicinity:** A space, within a location intended for the examination and treatment of patients, extending 6 ft (1.8 m) beyond the normal location of the patient bed, chair, table, treadmill, or other device that supports the patient during examination and treatment and extending vertically to 7 ft 6 in. (2.3 m) above the floor *»Article 100«*.



Ambulatory Health Care Occupancy

Where electrical life support equipment is required, the essential electrical distribution system shall comply with 517.29 through 517.30 *»517.45(B)«*.

Where Category 1 patient care spaces are present, the essential electrical distribution system shall comply with 517.29 through 517.30 *»517.45(C)«*.

Where Category 2 patient care spaces are present, the essential electrical distribution system shall comply with 517.40 through 517.45 *»517.45(D)«*.

If required, alternate power sources acceptable to the governing body shall comply with the requirements of NFPA 99-2021, Health Care Facilities Code *»517.45(E)«*.

Ⓐ **Ambulatory health care occupancy:** An occupancy used to provide simultaneous service (or treatment) to four or more patients that provides, on an outpatient basis, one or more of the following: (1) treatment for patients that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others;
(2) anesthesia that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others; or
(3) treatment for patients who, due to the nature of their injury or illness, are incapable of taking action for self-preservation under emergency conditions without the assistance of others *»Article 100«*.

Ⓑ If required by the governing body, the essential electrical distribution system for Category 3 patient care spaces shall be comprised of an alternate power system capable of supplying a limited amount of lighting and power service for the orderly cessation of procedures during a time normal electrical service is interrupted *»517.45(A)«*.

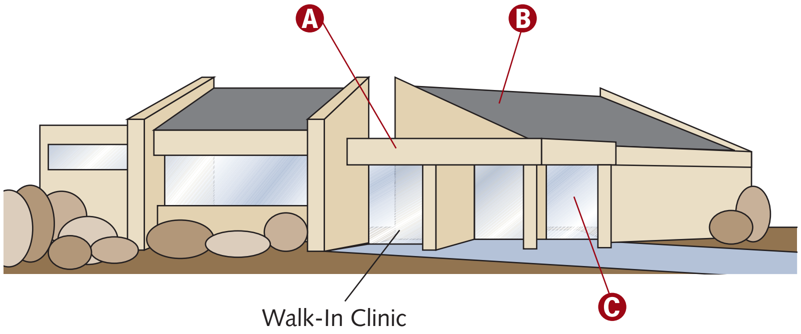
Ⓒ Ambulatory health care occupancy is included in the term **health care facilities.**

Note

Health care facility's governing body is defined as the person or persons who have the overall legal responsibility for the operation of a health care facility ***»Article 100«***.

Note

See NFPA 99-2021 *Health Care Facilities Code* ***»517.45(A) Informational Note«***.



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Electrical System Terminology

Electrical life-support equipment: Electrically powered equipment whose continuous operation is necessary to maintain a patient's life »*Article 100*«.

Isolated power system: A system consisting of an isolating transformer (or equivalent) and a line isolation monitor with its ungrounded circuit conductors »*Article 100*«. (See related definitions, which include: *hazard current, fault hazard current, monitor hazard current, total hazard current, and line isolation monitor.*)

Isolation transformer: A multiple-winding-type transformer, with physically separated primary and secondary windings that inductively couples its ungrounded secondary winding(s) to the grounded feeder system that energizes its primary winding(s) »*Article 100*«.

Ⓐ **Alternate power source:** One or more generator sets (or battery systems, where permitted) to provide power during normal electrical service interruption, or the public utility electrical service intended to provide power during interruption of service normally provided by on-site generating facilities »*Article 100*«.

Ⓑ **Critical branch:** A system of feeders and branch circuits supplying power for task illumination, fixed equipment, select receptacles, and select power circuits serving areas and functions related to patient care and that are automatically connected to alternate power sources by one or more transfer switches during interruption of normal power source »*Article 100*«.

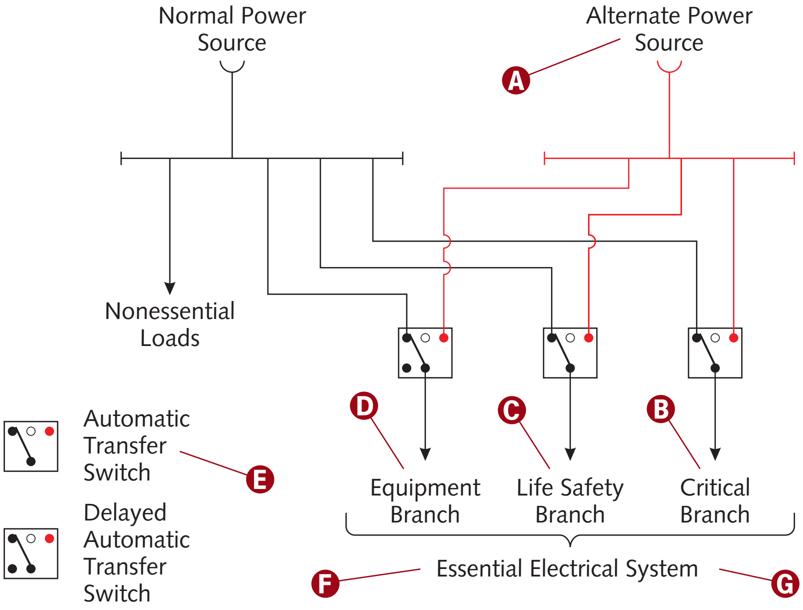
Ⓒ **Life safety branch:** A system of feeders and branch circuits supplying power for lighting, receptacles, and equipment essential for life safety that is automatically connected to alternate power sources by one or more transfer switches during interruption of the normal power source »*Article 100*«.

Ⓓ **Equipment branch:** A system of feeders and branch circuits arranged for delayed, automatic, or manual connection to the alternate power source, primarily serving 3-phase power equipment »*Article 100*«.

Ⓔ The number of transfer switches to be used shall be based on reliability and design. Each branch of the essential electrical system shall have one or more transfer switches. One transfer switch shall be permitted to serve one or more branches in a facility with a continuous load on the switch of 150 kVA (120 kW) or less »*517.31(B)*«.

Ⓕ **Essential electrical system:** A system comprising alternate power sources and all connected distribution systems (and ancillary equipment), designed both to ensure electrical power continuity to designated areas and functions of a health care facility during disruption of normal power sources and to minimize disruption within the internal wiring system »*Article 100*«.

Ⓖ Type 1 and Type 2 essential electrical systems (EES) for health care facilities shall comprise separate branches capable of supplying a limited amount of lighting and power service, which is considered essential for life safety and orderly cessation of procedures during the time normal electrical service is interrupted for any reason »*517.25*«.



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Grounding and Bonding

For other than isolated ground receptacles, an insulated equipment bonding jumper that directly connects to the equipment grounding conductor is permitted to connect the box and receptacle(s) to the equipment grounding conductor. Isolated ground receptacles shall be connected in accordance with 517.16 »*517.13(B)(1) Exception No. 1*«.

Metal faceplates shall be connected to an effective ground-fault current path by means of metal mounting screw(s) securing the faceplate to a metal outlet box (or metal yoke or strap of a receptacle) »*517.13(B)(1) Exception No. 2*«.

Luminaires more than 7½ ft (2.3 m) above the floor and switches located outside the patient care vicinity shall be permitted to be connected to an equipment grounding return path complying with 517.13(A) or (B) »*517.13 Exception*«.

Patient equipment grounding point: A jack or terminal bus that serves as the collection point for electric appliance redundant grounding in a patient care vicinity, or for grounding other items to eliminate electromagnetic interference problems »*Article 100*«.

Reference grounding point: The ground bus of the panelboard or isolated power system panel supplying a patient care room »*Article 100*«.

Exposed conductive surfaces: Those unprotected, uninsulated, unenclosed, or unguarded surfaces capable of carrying electric current and permitting personal contact. Paint, anodizing, and similar coatings do not provide suitable insulation unless listed for such use »*Article 100*«.

Ⓐ In Category 2 spaces and Category 1 spaces, all patient bed location receptacles shall be listed "hospital grade" and shall be so identified »*517.18(B)(2)* and *517.19(B)(2)*«.

Ⓑ An isolated grounding receptacle shall not be installed inside a patient care vicinity »*517.16(A)*«. Isolated ground receptacle(s) installed in patient care spaces outside of a patient care vicinity(s) shall comply with 517.16(B)(1) and (2). For requirements pertaining to isolated ground receptacles, in other than patient care vicinities, see 250.146(D) and 408.40 Exception.

Ⓒ Normal and essential branch-circuit panelboard equipment grounding terminal buses serving the same individual patient care vicinity shall be connected together with an insulated continuous copper conductor no smaller than 10 AWG. Where two or more panelboards serving the same individual patient care vicinity are served from separate transfer switches on the essential electrical system, the equipment grounding terminal buses of those panelboards shall be connected together with an insulated continuous copper conductor not smaller than 10 AWG. This conductor can be broken in order to terminate on the equipment grounding terminal bus in each panelboard »*517.14*«.

Ⓓ Unless meeting one of the two exceptions, the following shall be connected to an insulated copper equipment grounding conductor that is clearly identified along its entire length by green insulation and installed with the branch circuit conductors in the wiring methods as provided in 517.13(A):

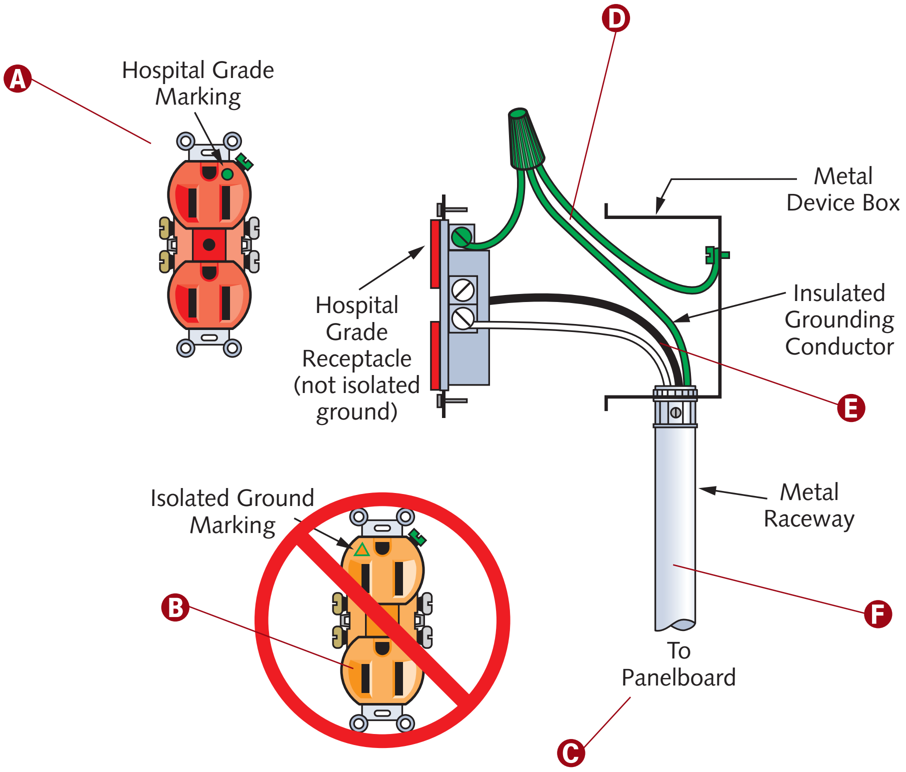
(1) The grounding terminals of all receptacles other than isolated ground receptacles

(2) Metal outlet boxes, metal device boxes, or metal enclosures

(3) All non-current-carrying conductive surfaces of fixed electrical equipment likely to become energized that are subject to personal contact, operating at over 100 volts »*517.13(B)(1)*«.

Ⓔ Equipment grounding conductors and equipment bonding jumpers shall be sized in accordance with 250.122 »*517.13(B)(2)*«.

Ⓕ All branch circuits serving patient care spaces shall be provided with an effective ground-fault current path by installation in a metal raceway system or a cable having a metallic armor or sheath assembly. The metal raceway system, or metallic cable armor or sheath assembly, shall qualify as an equipment grounding conductor according to 250.118 »*517.13(A)*«.



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Ground-Fault Protection

Ground-fault protection for the service and feeder disconnecting means operation shall be fully selective so that the feeder device, and not the service device, opens for ground faults on the feeder device's load side. Separation of ground-fault protection time-current characteristics shall conform to manufacturer's recommendations and shall consider all required tolerances and disconnect operating time to achieve 100% selectivity »*517.17(C)*«.

On installation of equipment ground-fault protection, each level shall be performance tested to ensure compliance with 517.17(C) »*517.17(D)*«.

Ⓐ Where ground-fault protection is provided for service disconnecting means (or feeder disconnecting means) operation as specified by 230.95 or 215.10, an additional ground-fault protection step shall be provided in the next level of feeder disconnecting means downstream toward the load. Such protection shall consist of overcurrent devices and current transformers (or other equivalent protective equipment) that shall cause the feeder disconnecting means to open.

The additional levels of ground-fault protection shall not be installed on the load side of an essential electrical system transfer switch »*517.17(B)*«.

Ⓑ Ground-fault protection of equipment is defined as a system intended to provide protection of equipment from damaging line-to-ground fault currents by operating to cause a disconnecting means to open all ungrounded conductors of the faulted circuit. This protection is provided at current levels less than those required to protect conductors from damage through the operation of a supply circuit overcurrent device »*Article 100*«.

Ⓒ Ground-fault protection of equipment shall be provided for solidly grounded wye electric services of more than 150 volts to ground but not exceeding 1000 volts phase-to-phase for each service disconnect rated 1000 amperes or more. The grounded conductor for the solidly grounded wye system shall be connected directly to ground through a grounding electrode system, as specified in 250.50, without inserting any resistor or impedance device »*230.95*«.

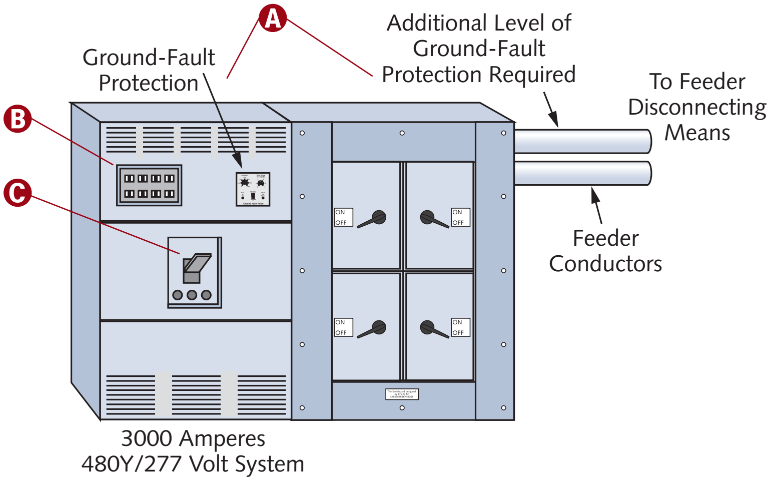
The rating of the service disconnect shall be considered to be the rating of the largest fuse that can be installed or the highest continuous current trip setting for which the actual overcurrent device installed in a circuit breaker is rated or can be adjusted »*230.95*«.

Note

The requirements of 517.17 apply to buildings or portions of buildings containing health care facilities with Category 1 spaces or utilizing electrical life-support equipment and buildings that provide the required essential utilities or service for the operation of Category 1 spaces or electrical life-support equipment »***517.17(A)***«.

Note

Each branch-circuit disconnecting means rated 1000 A or more and installed on solidly grounded wye electrical systems of more than 150 volts to ground, but not exceeding 1000 volts phase-to-phase, shall be provided with ground-fault protection of equipment in accordance with the provisions of 230.95 »***210.13***«.


A
Additional Level of Ground-Fault Protection Required
Ground-Fault Protection
To Feeder Disconnecting Means
B
C
Feeder Conductors
3000 Amperes
480Y/277 Volt System

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Wet Procedure Locations

The health care facility's governing body designates patient care space in accordance with the type of patient care anticipated »*Article 100 Patient Care Space, Informational Note No. 1*«.

If an isolated power system is utilized, the isolated power equipment shall be listed as isolated power equipment and the isolated power system shall be designed and installed in accordance with 517.160 »*517.20(B)*«.

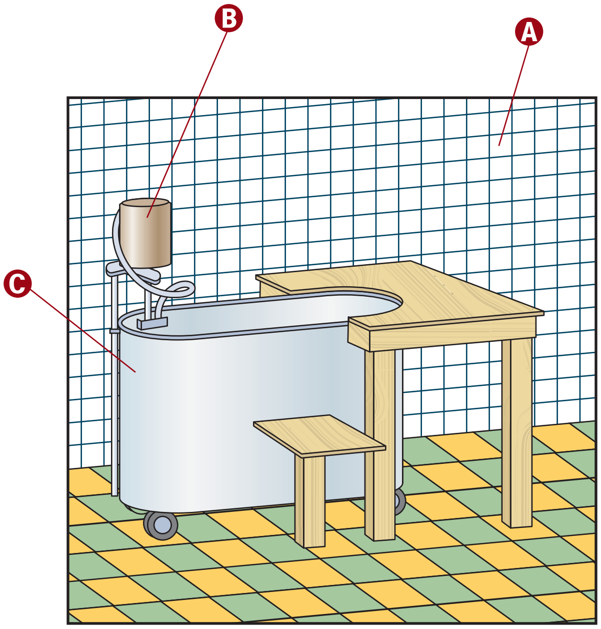
A **Wet procedure locations:** The area in a patient care space where a procedure is performed that is normally subject to wet conditions while patients are present, including standing fluids on the floor or drenching of the work area, either of which condition is intimate to the patient or staff »*Article 100*«. Routine housekeeping procedures and incidental spillage of liquids do not define a wet procedure location »*Article 100 Wet Procedure Location, Informational Note*«.

B Branch circuits supplying only listed, fixed, therapeutic, and diagnostic equipment can be supplied from a grounded service, single- or 3-phase system, provided that (1) wiring for grounded and isolated circuit wiring does not occupy the same raceway and (2) all conductive equipment surfaces are connected to an insulated copper equipment grounding conductor »*517.20(A) Exception*«.

C For requirements for installation of therapeutic pools and tubs, see Part VI of Article 680.

Warning

Wet procedure locations shall be provided with special protection against electric shock by one of the following means: (1) isolated power systems that remain in operation in the event of a single line-to-ground fault condition that inherently limits the possible ground-fault current due to a first fault to a low value, without interrupting the power supply and (2) power distribution system in which the power supply is interrupted if the ground-fault current does, in fact, exceed a value of 6 milliamperes (mA) »*517.20(A)*«.



Patient Care Spaces

Patient Bed Location Branch Circuits—Category 2 Spaces

Section 517.18(A) requirements do not apply to patient bed locations in clinics, medical/dental offices, and outpatient facilities; psychiatric, substance abuse, and rehabilitation hospitals; sleeping rooms of nursing homes; and limited-care facilities where 517.10(B)(2) requirements are met »*517.18(A) Exception No. 2*«.

A Branch circuits serving only special-purpose outlets or receptacles (such as portable X-ray outlets) do not require service from the same distribution panel(s) »*517.18(A) Exception No. 1*«.

B Each patient bed location shall be supplied by at least two branch circuits: one from the critical branch and one from the normal system. All normal system branch circuits must originate within the same panelboard »*517.18(A)*«.

C The electrical receptacles or the cover plate for the electrical receptacles supplied from the critical branch shall have a distinctive color or marking so as to be readily identifiable and shall also indicate the panelboard and branch-circuit number supplying them »*517.18(A)*«.

D A Category 2 patient bed location served from two separate transfer switches on the critical branch shall not be required to have circuits from the normal system »*517.18(A) Exception No. 3*«.

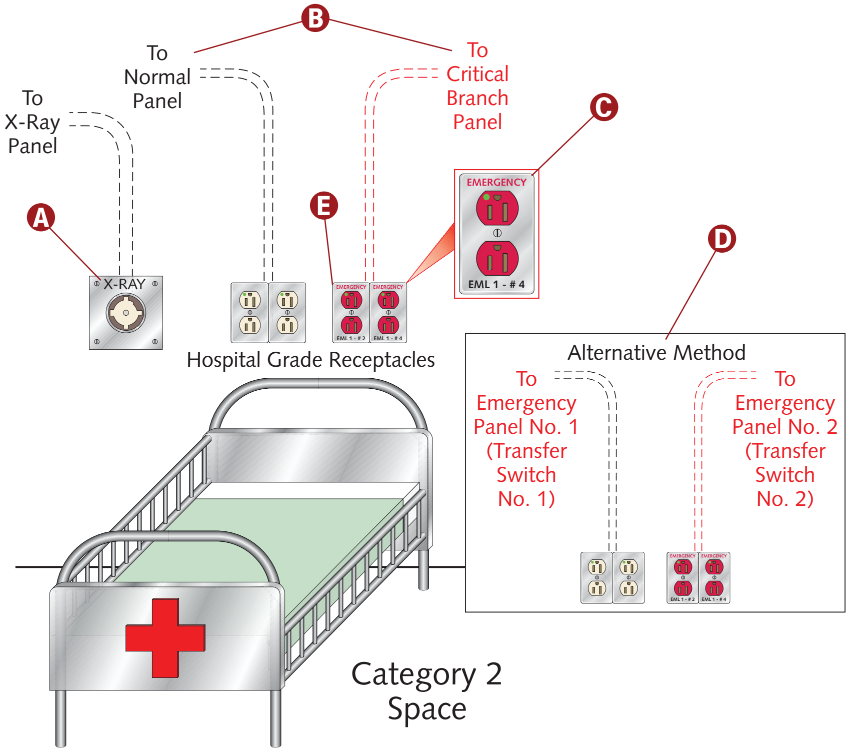
E Each patient bed location shall be provided with a minimum of eight receptacles »*517.18(B)(1)*«.

Patient Bed Location Branch Circuits—Category 2 Spaces *(continued)*

Note

Category 2 space is defined as space in which failure of equipment or a system is likely to cause minor injury to patients, staff, or visitors ***»Article 100«***.

Category 2 spaces were formerly known as general care rooms. Examples include, but are not limited to, inpatient bedrooms, dialysis rooms, in vitro fertilization rooms, procedural rooms, and similar rooms ***»Article 100 Informational Note under the definition of Category 2 Space, under the definition of Patient Care Space«***.


B
To X-Ray Panel
To Normal Panel
To Critical Branch Panel
C
A
E
X-RAY
EMERGENCY
EML 1 - # 2
EML 1 - # 4
D
Hospital Grade Receptacles
Alternative Method
To Emergency Panel No. 1 (Transfer Switch No. 1)
To Emergency Panel No. 2 (Transfer Switch No. 2)
Category 2 Space

Warning

Branch circuits serving patient bed locations shall not be part of a multiwire branch circuit *»517.18(A)«*.

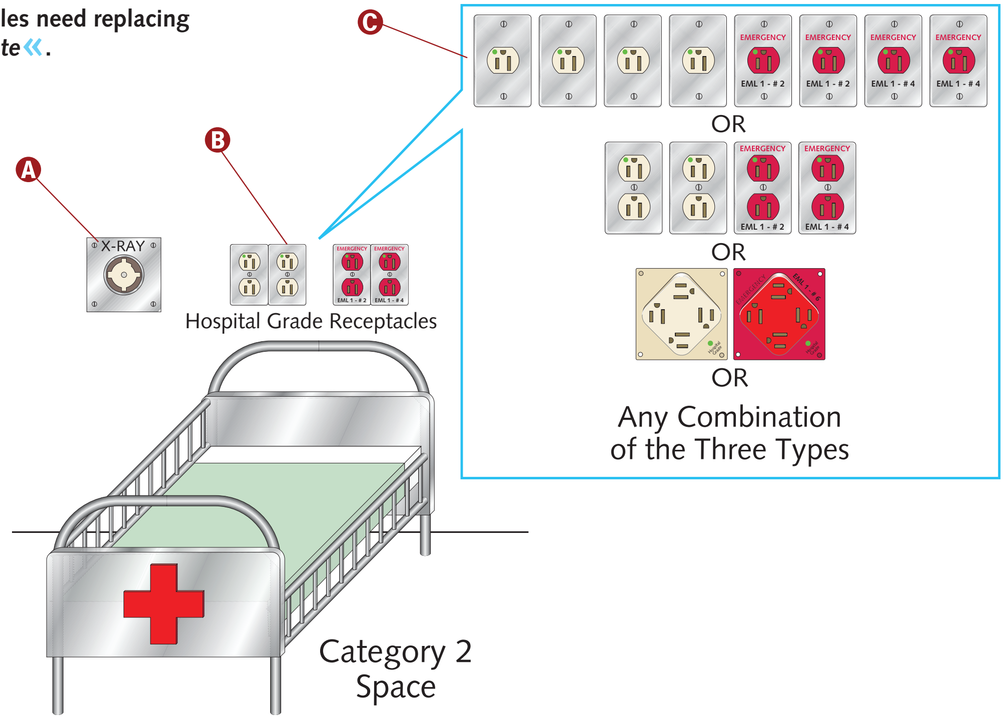
Patient Bed Location Receptacles—Category 2 Spaces

A total, immediate replacement of existing non-hospital grade receptacles is not necessary. It is intended, however, that non-hospital grade receptacles be replaced with hospital grade receptacles on modification of use, or during renovation, or as receptacles need replacing *»517.18(B)(2) Informational Note«*.

A Special-purpose receptacles are not counted as required receptacles.

B *Each* patient bed location shall be provided with a minimum of eight receptacles *»517.18(B)(1)«*.

C The eight receptacles can be either single, duplex, or quadruplex type, or any combination of the three types *»517.18(B)(2)«*.


C
A
B
X-RAY
Hospital Grade Receptacles
EMERGENCY
EML 1 - # 2
EML 1 - # 4
OR
OR
OR
Any Combination of the Three Types
Category 2 Space

Note

All receptacles shall be listed "hospital grade" and shall be so identified. The grounding terminal of each receptacle shall be connected to an insulated copper equipment grounding conductor sized in accordance with Table 250.122 ***»517.18(B)(2)«***.

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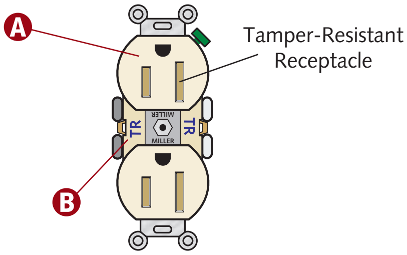
Pediatric Location Receptacles—Designated Category 2

A Receptacles that are located within the patient rooms, bathrooms, playrooms, and activity rooms of pediatric units or spaces with similar risk as determined by the governing body, other than infant nurseries, shall be listed tamper-resistant or shall employ a listed tamper-resistant cover »*517.18(C)*«.

B Tamper-resistant receptacles are identified by the letters "TR" or the words *Tamper Resistant*. After the receptacle has been installed, the identification is only required to be visible with the cover plate removed. See UL (Underwriter Laboratories) White Book, category: Receptacles for Plugs and Attachment Plugs (RTRT).



Patient Bed Location Receptacles—Category 1 Spaces

All receptacles shall be listed "hospital grade" and shall be so identified. The grounding terminal of each receptacle shall be connected to the reference grounding point by means of an insulated copper equipment grounding conductor »*517.19(B)(2)*«.

Although not required, a patient care vicinity shall be permitted to have a patient equipment grounding point. Where one is supplied, it can contain one (or more) listed grounding and bonding jacks. An equipment bonding jumper no smaller than 10 AWG shall connect the grounding terminal of all grounding-type receptacles to the patient equipment grounding point. The bonding conductor can be arranged centrically or looped as convenient »*517.19(D)*«.

Where there is no patient equipment grounding point, it is important that the distance between the reference grounding point and the patient care vicinity be as short as possible to minimize any potential differences »*517.19(D) Informational Note*«.

A The equipment grounding conductor for special-purpose receptacles (such as the operation of mobile X-ray equipment) shall extend to the branch-circuit reference grounding points for all locations potentially served from such receptacles. Where an isolated ungrounded system serves such a circuit, the grounding conductor does not have to run with the power conductors; however, the special-purpose receptacle's equipment grounding terminal shall connect to the reference grounding point »*517.19(H)*«.

B Each patient bed location shall have a minimum of fourteen receptacles. At least one of the receptacles must be connected to (1) the normal system branch circuit as required by 517.19(A) or (2) a critical branch circuit supplied by a different transfer switch not associated with other receptacles at the same patient bed location »*517.19(B)(1)*«.

C The fourteen receptacles can be either single, duplex, or quadruplex type, or any combination of the three »*517.19(B)(2)*«.

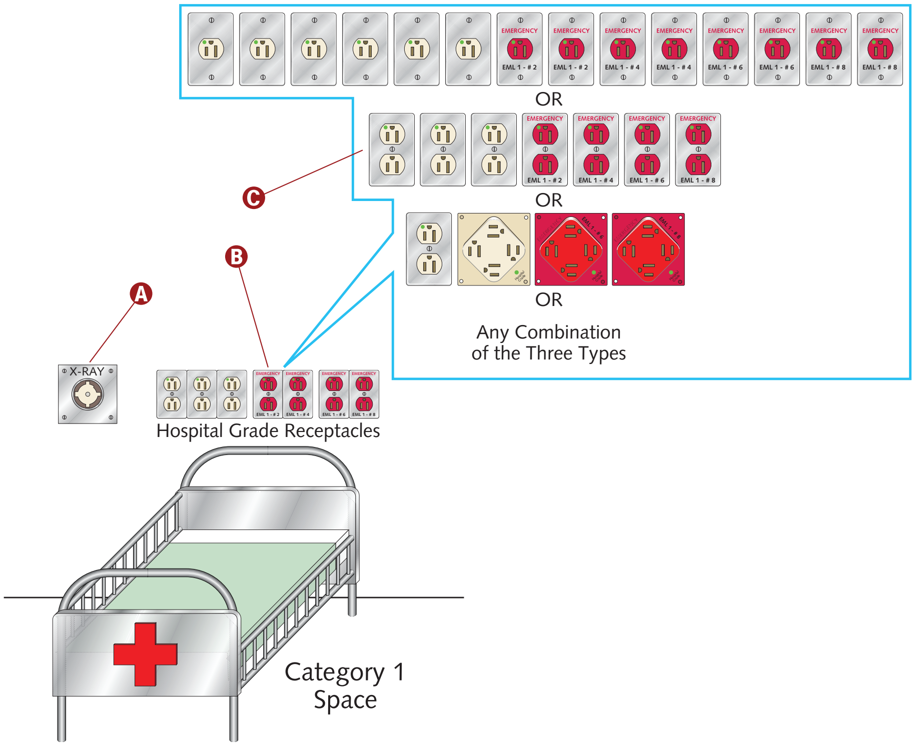
Note

Where a grounded electrical distribution system is used and metal feeder raceway or Type MC or MI cable that qualifies as an equipment grounding conductor in accordance with 250.118 is installed, grounding of enclosures and equipment, such as panelboards, switchboards, and switchgear, shall be ensured by one of the following bonding means at each termination or junction point of the metal raceway or Type MC or MI cable:

(1) A grounding bushing and a continuous copper bonding jumper, sized according to 250.122, with the bonding jumper connected to the junction enclosure or the panel ground bus.

(2) Connection of feeder raceways or Type MC or MI cables to threaded hubs or bosses on terminating enclosures.

(3) Other approved devices such as bonding-type locknuts or bushings. Standard locknuts shall not be used for bonding »*517.19(E)*«.



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Patient Bed Location Branch Circuits—Category 1 Spaces

A Branch circuits serving only special-purpose receptacles or equipment in Category 1 spaces can be served by other panelboards »*517.19(A) Exception No. 1*«.

B Each patient bed location shall be supplied by at least two branch circuits: one (or more) from the critical branch and one (or more) from the normal system. At least one branch circuit from the critical branch shall supply outlet(s) at that bed location only »*517.19(A)*«.

C Critical branch receptacles shall be identified and shall also indicate the supplying panelboard and circuit number »*517.19(A)*«.

D The cover plates for the electrical receptacles or the electrical receptacles themselves supplied from the life safety and critical branches shall have a distinctive color or marking so as to be readily identifiable »*517.19(A)* and *517.31(E)*«.

E Category 1 spaces served from two separate critical branch transfer switches shall not be required to have circuits from the normal system »*517.19(A) Exception No. 2*«.

F Each patient bed location shall be provided with a minimum of fourteen receptacles »*517.19(B)(1)*«.

Note

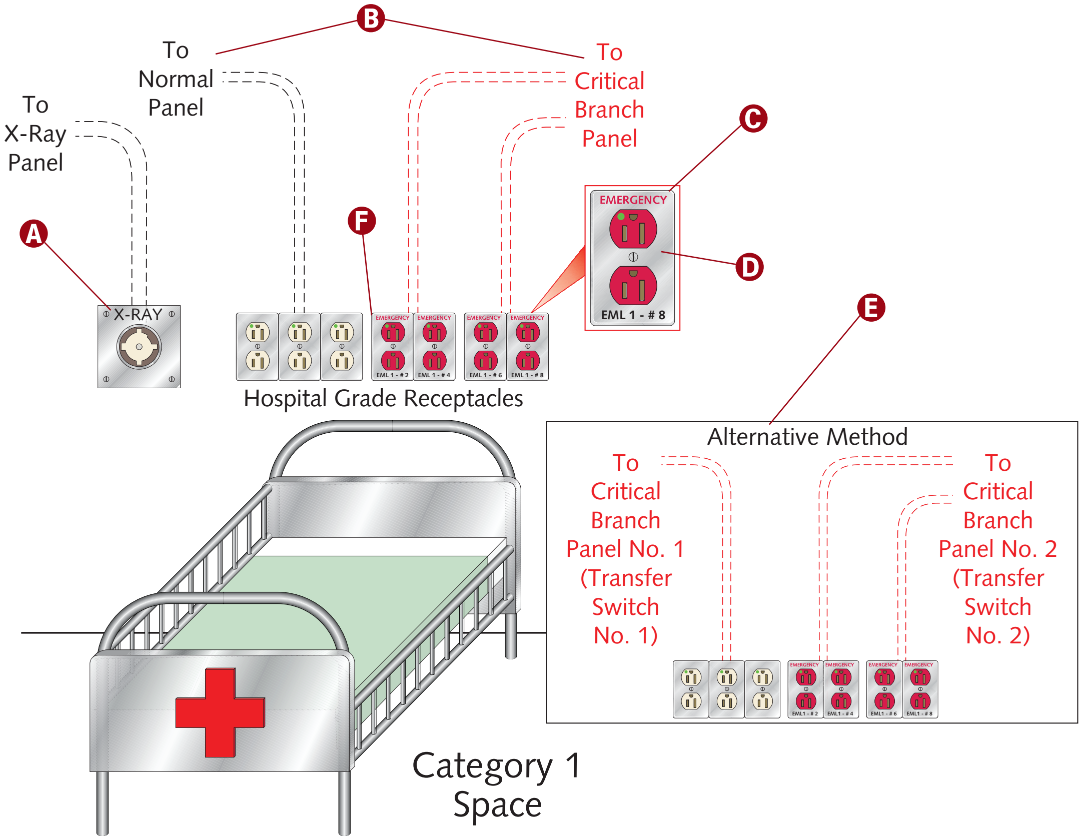
Category 1 space is the space in which failure of equipment or a system is likely to cause major injury or death to patients, staff, or visitors. Category 1 space is one of the four spaces within the patient care space »***Article 100 (under the definition of Patient Care Space)***«. Category 1 spaces, formerly known as critical care rooms, are typically where patients are intended to be subjected to invasive procedures and connected to line-operated, patient care–related appliances. Examples include, but are not limited to, special care patient rooms used for critical care, intensive care, and special care treatment rooms such as angiography laboratories, cardiac catheterization laboratories, delivery rooms, operating rooms, post-anesthesia care units, trauma rooms, and other similar rooms »***Informational Note under the definition of Category 1 Space, under the definition of Patient Care Space***«.

Warning

The branch circuit serving patient bed locations shall not be part of a multiwire branch circuit »*517.19(A)*«.

Caution

All normal system branch circuits shall originate from a single panelboard »*517.19(A)*«.



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Operating Room Receptacles

Ⓐ Each operating room shall be provided with a minimum of thirty-six receptacles divided between at least two branch circuits. At least twelve receptacles, but no more than twenty-four receptacles, shall be connected to either of the following:

(1) The normal system branch circuit required in 517.19(A).

(2) A critical branch circuit supplied by a different transfer switch than the other receptacles at the same location »*517.19(C)(1)*«.

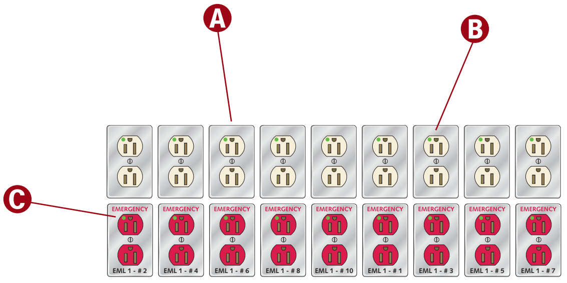
Note

The grounding terminal of each receptacle shall be connected to the reference grounding point by means of an insulated copper equipment grounding conductor ***»517.19(C)(2)«***.

The reference grounding point is defined as the ground bus of the panelboard or isolated power system panel supplying the patient care room ***»Article 100«***.

Ⓑ The receptacles required in 517.19(C)(1) shall be permitted to be of the locking or nonlocking type, single, duplex, or quadruplex types or any combination of the three »*517.19(C)(2)*«.

Ⓒ All nonlocking-type receptacles shall be listed hospital grade and so identified »*517.19(C)(2)*«.



Hospital Grade Receptacles

Hospitals

Life Safety Branch

Ⓐ The life safety branch shall be limited to circuits essential to life safety. No functions other than those listed in 517.33(A) through (H) shall be connected to the life safety branch »*517.33*«.

Ⓑ Illumination of egress means is required, such as lighting for corridors, passageways, stairways, landings at exit doors, and all paths of approach to exits shall be connected to the life safety branch. Switching arrangements to transfer patient corridor lighting from general illumination to night illumination circuits is permitted, provided only one of two circuits can be selected and both circuits cannot be simultaneously extinguished »*517.33(A)*«.

Ⓒ Task illumination, battery charger for emergency battery-powered lighting unit(s), and select receptacles at the generator set location and essential electrical system transfer switch locations shall be connected to the life safety branch »*517.33(E)*«. Generator set accessories as required for generator performance shall be connected to the life safety branch. Loads dedicated to a specific generator, including the fuel transfer pump(s), ventilation fans, electrically operated louvers, controls, cooling system, and other generator accessories essential for generator operation, shall be connected to the life safety branch or to the output terminals of the generator with overcurrent protective devices »*517.33(F)*«.

Ⓓ Exit and exit directional signs shall be connected to the life safety branch »*517.33(B)*«.

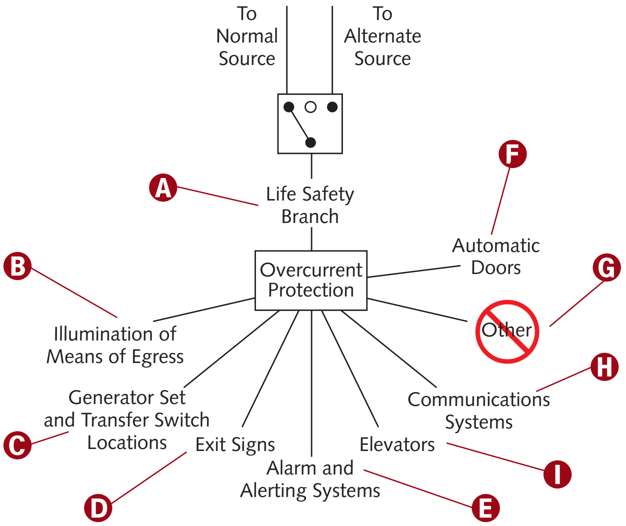
Ⓔ Alarm and alerting systems, including (1) fire alarm systems, (2) alarm and alerting systems (other than fire alarm systems) shall be connected to the life safety branch or critical branch, (3) alarms for systems used for piping of nonflammable medical gases, and (4) mechanical, control, and other accessories required for effective life safety systems operation, shall be permitted to be connected to the life safety branch »*517.33(C)*«.

Ⓕ Electrically powered doors used for building egress shall be connected to the life safety branch »*517.33(H)*«.

Ⓖ Only functions listed in 517.33(A) through (H) shall be connected to the life safety branch of the essential electrical system »*517.33*«.

Ⓗ Hospital communication systems used for issuing instructions during emergency conditions shall be connected to the life safety branch »*517.33(D)*«.

Ⓘ Elevator cab lighting, control, communications, and signal systems shall be connected to the life safety branch »*517.33(G)*«.



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Essential Electrical Systems (Greater than 150 kVA)

A Hospital power sources and alternate power sources shall be permitted to serve the essential electrical systems of contiguous or same site facilities »*517.31(B)(2)*«.

B Demand calculations for sizing of the alternate power source(s) shall be based on any of the following:

(1) Prudent demand factors and historical data

(2) Connected load

(3) Feeder calculations

(4) Any combination of the above »*517.31(D)*«.

C Loads served by generating equipment not specifically named in Article 517 shall be served by their own transfer switches so that these loads (1) are not transferred if the transfer will overload the generating equipment and (2) are automatically shed on generating equipment overloading »*517.31(B)(1)*«.

D The number of transfer switches to be used shall be based on reliability and design. Each branch of the essential electrical system shall have one or more transfer switches »*517.31(B)*«.

E Those functions of patient care depending on lighting or appliances that are connected to the essential electrical system shall be divided into the life safety branch and the critical branch, as described in 517.33 and 517.34. The life safety and critical branches shall be installed and connected to the alternate power source specified in 517.41(A) and (B) so that all functions specified herein for the life safety and critical branches are automatically restored to operation within 10 seconds after interruption of the normal source »*517.32(A)* and *(B)*«.

F Type 1 essential electrical systems for hospitals shall be comprised of three separate branches capable of supplying a limited amount of lighting and power service that is considered essential for life safety and effective hospital operation during the time the normal electrical service is interrupted for any reason. The three branches are life safety, critical, and equipment »*517.31(A)*«.

G The essential electrical system shall have the capacity and rating to meet the maximum actual demand likely to be produced by the connected load. Feeders shall be sized in accordance with 215.2 and Part III of Article 220. The alternate power source(s) shall have the capacity and rating to meet the demand produced by the load at any given time »*517.31(D)*«.

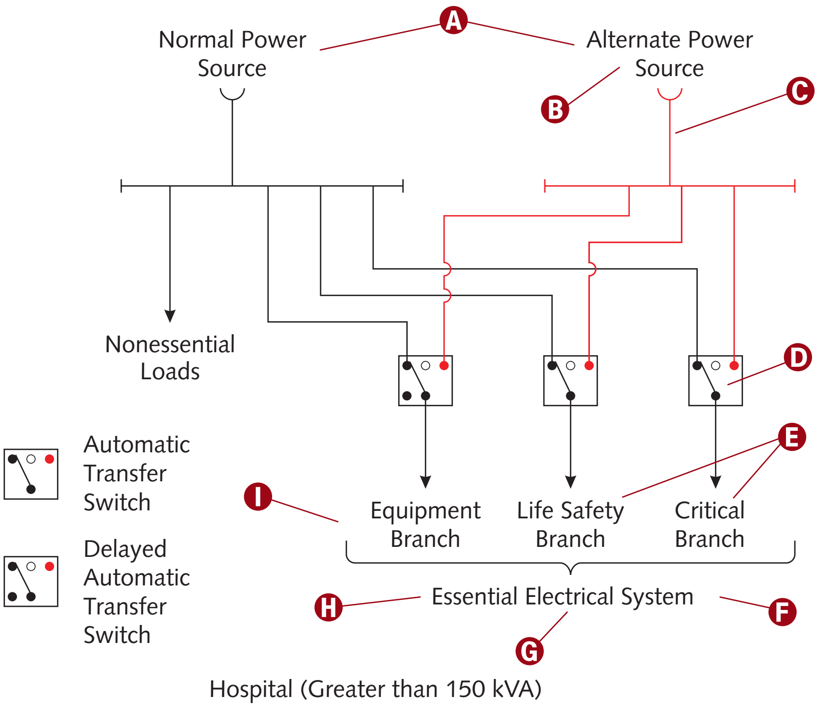
H The wiring of the life safety and critical branches shall be mechanically protected. The permitted wiring methods are listed in 517.31(C)(3)(1) through (5) »*517.31(C)(3)*«.

I Wiring of the life safety branch and the critical branch shall be permitted to occupy the same raceways, boxes, or cabinets of other circuits not part of the branch where such wiring complies with one of the following:

1. Is in transfer equipment enclosures
2. Is in exit or emergency luminaires supplied from two sources
3. Is in a common junction box attached to exit or emergency luminaires supplied from two sources
4. Is for two or more circuits supplied from the same branch and same transfer switch »*517.31(C)(1)*«.

Note

Where isolated power systems are installed in any of the areas in 517.34(A)(1) and (A)(2), each system shall be supplied by an individual circuit serving no other load **»*517.31(C)(2)*«**.



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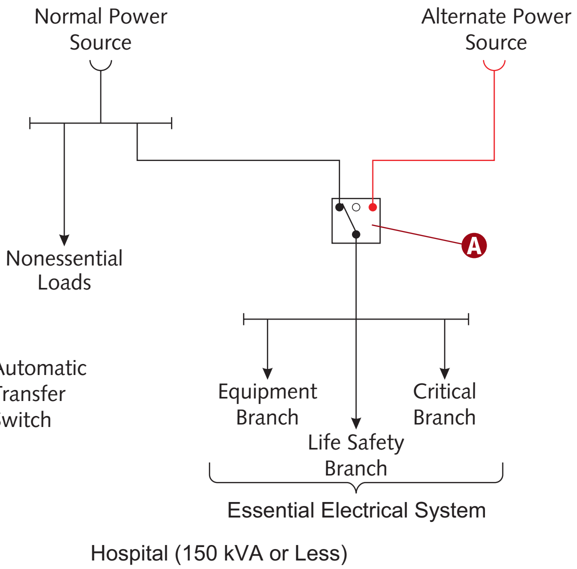
Essential Electrical Systems (150 kVA or Less)

A One transfer switch and downstream distribution system shall be permitted to serve one or more branches in a facility with a continuous load on the switch of 150 kVA (120 kW) or less »*517.31(B)*«.

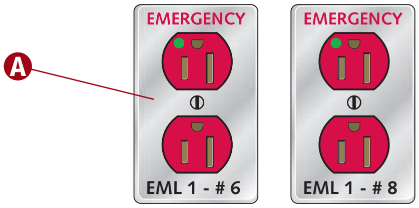
Note

For essential electrical systems under 150 kVA, deletion of the time-lag intervals feature for delayed automatic connection to the equipment branch shall be permitted ***»517.35 Exception«***.



Receptacle Identification

A The cover plates for the electrical receptacles or the electrical receptacles themselves supplied from the life safety and critical branches shall have a distinctive color or marking so as to be readily identifiable »*517.31(E)*«.



Critical Branch

A The critical branch of the essential electrical system shall supply power for task illumination, fixed equipment, select receptacles, and select power circuits serving patient care spaces and function as listed in 517.34(A)(1) through (10) »*517.34(A)*«.

B Category 1 spaces where deep sedation or general anesthesia is administered, including task illumination, selected receptacles, and fixed equipment, shall be connected to the critical branch »*517.34(A)(1)*«.

C Clinical IT-network equipment shall be connected to the critical branch »*517.34(A)(8)*«.

D Additional specialized patient care task illumination and receptacles, where needed, shall be connected to the critical branch »*517.34(A)(3)*«.

E Patient care spaces, including task illumination and select receptacles, in the following: (a) patient care spaces, including infant nurseries, select acute nursing areas, psychiatric bed areas (omit receptacles), and ward treatment rooms; (b) medication preparation spaces; (c) pharmacy dispensing spaces; (d) nurses' stations (unless adequately lighted by corridor luminaires) shall be connected to the critical branch »*517.34(A)(2)*«.

F Subdividing the critical branch into two or more branches is permitted »*517.34(C)*«.

G Additional task illumination, receptacles, and select power circuits needed for effective facility operation, including single-phase fractional horsepower motors can be connected to the critical branch »*517.34(A)(10)*«.

H Task illumination, select receptacles, and select power circuits for the following shall be connected to the critical branch: (a) Category 1 or Category 2 spaces with at least one duplex receptacle per patient bed location, and task illumination as required by the governing body of the health care facility; (b) angiographic labs; (c) cardiac catheterization labs; (d) coronary care units; (e) hemodialysis rooms or areas; (f) emergency room treatment areas (select); (g) human physiology labs; (h) intensive care units; and (i) postoperative recovery rooms (select) »*517.34(A)(7)*«.

Note

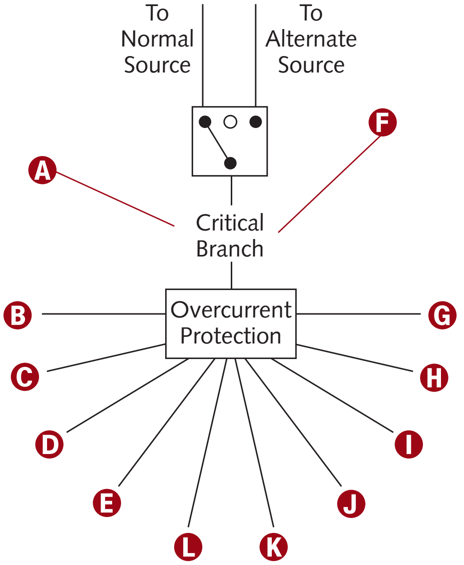
It shall be permitted to control task illumination on the critical branch ***»517.34(B)«***.

I Telecommunications entrance facility, telecommunications equipment rooms, and telecommunications rooms and equipment in these rooms shall be connected to the critical branch »*517.34(A)(6)*«.

J Blood, bone, and tissue banks shall be connected to the critical branch »*517.34(A)(5)*«.

K Nurse call systems shall be connected to the critical branch »*517.34(A)(4)*«.

L Wireless phone and paging equipment for clinical staff communications shall be connected to the critical branch »*517.34(A)(9)*«.



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Power Sources

Facilities whose normal power source is supplied by multiple separate central station-fed services experience greater than normal electrical service reliability than those having only a single feed. Such a dual source of normal power consists of multiple electrical services fed from separate generator sets, or a utility distribution network having multiple power input sources. These dual services are arranged to provide mechanical and electrical separation when a fault between the facility and the generating sources is unlikely to cause an interruption of more than one of the facility service feeders »*517.30(C)(2) Informational Note*«.

Note

Essential electrical system components shall be located to minimize interruptions caused by natural forces common to the area (such as storms, floods, earthquakes, or hazards created by adjoining structures or activities). Installation of electrical services shall be located to reduce possible interruption of normal electrical services resulting from similar causes as well as possible disruption of normal electrical service due to internal wiring and equipment failures. Feeders shall be located to provide physical separation of the feeders of the alternate source and from the feeders of the normal electrical source to prevent possible simultaneous interruption ***»517.30(C)«***.

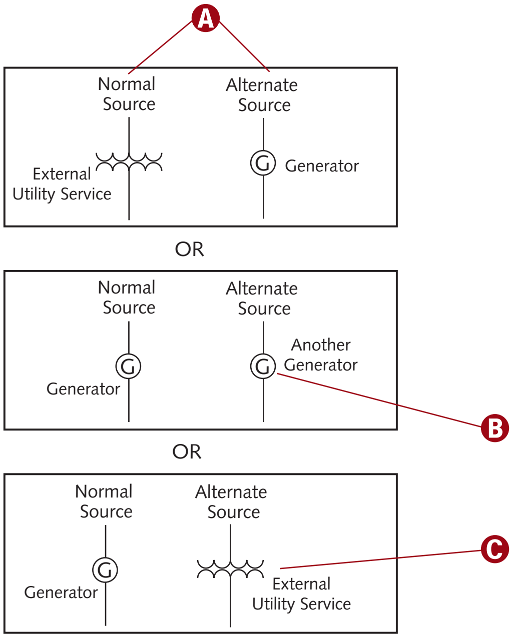
Note

Fuel cell systems shall be permitted to serve as the alternate source for all or part of an essential electrical system, provided the conditions in 517.30(B)(3)(a) through (e) apply ***»517.30(B)(3)«***.

Ⓐ Essential electrical systems shall have a minimum of two independent sources of power. One on-site source (or sets of sources) shall be sized to supply the entire essential electrical system. The other independent source (or sets of sources) shall be sized to supply the entire essential electrical system and shall be permitted to be located on-site or off-site. Additional sources other than the first two independent sources shall be permitted to be sized to supply the intended load »*517.30(A)*«.

Ⓑ Two separate generators meet the requirements of 517.30(A) »*517.30(B)*«.

Ⓒ Where utility power is used as the normal source, utility power shall not be used as the alternate source unless permitted elsewhere in Article 517 »*517.30(B)(1)*«.



Equipment Branch

Deletion of the time-lag intervals feature for delayed automatic connection to the equipment system shall be permitted for essential electrical systems under 150 kVA »*517.35 Exception*«.

Ⓐ The following equipment shall be permitted to be arranged for either delayed automatic or manual connection to the alternate power source:

1. Heating equipment to provide heat for operating, delivery, labor, recovery, intensive care, coronary care, nurseries, infection/isolation rooms, emergency treatment spaces, general patient rooms, and pressure maintenance (jockey or make-up) pump(s) for water-based fire protection systems (see exception).
2. Elevator(s) providing service to patient, surgical, obstetrical, and ground floors during normal power interruption. (Where interruption of normal power would result in other elevators stopping between floors, throw-over facilities shall be provided to allow temporary operation of any elevator for patient/other person release.)
3. Hyperbaric facilities.
4. Hypobaric facilities.
5. Automatically operated doors.
6. Minimal electrically heated autoclaving equipment can be arranged for either automatic or manual connection to the alternate source.
7. Controls for equipment listed in 517.35.
8. Other selected equipment can be served by the equipment system »*517.35(B)*«.

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Equipment Branch *(continued)*

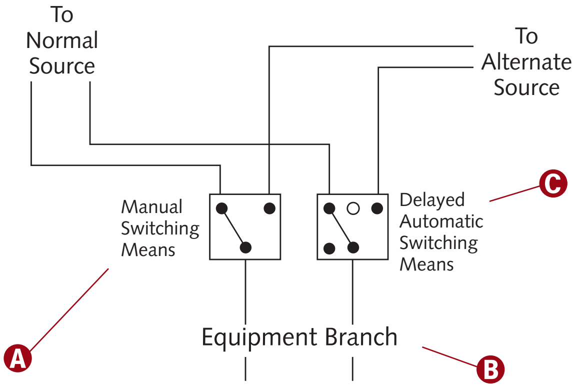
Ⓑ The equipment branch shall be installed and connected to the alternate power source such that the equipment described in 517.35(A) is automatically restored to operation at appropriate time-lag intervals following the energizing of the life safety and critical branches. Its arrangement shall also provide for the subsequent connection of equipment described in 517.35(B) *»517.35«*.

Ⓒ Delayed automatic connection to the alternate power source shall be permitted to be arranged for the following equipment:

1. Central suction systems serving medical/surgical functions, including controls. (Such suction systems are permitted on the critical branch.)
2. Sump pumps and other equipment required for the safe operation of major apparatus, including associated control systems and alarms.
3. Compressed air systems serving medical/surgical functions, including controls. (Such air systems are permitted on the critical branch.)
4. Smoke control, stair pressurization systems, or both.
5. Kitchen hood supply, exhaust systems, or both, if operation is required during a fire in (or under) the hood.
6. Supply return, and exhaust ventilating systems for airborne infectious/isolation rooms, protective environment rooms, exhaust fans for laboratory fume hoods, nuclear medicine areas where radioactive material is used, ethylene oxide evacuation, and anesthesia evacuation. Where delayed automatic connection is not appropriate, such ventilation systems shall be permitted to be placed on the critical branch.
7. Supply, return, and exhaust ventilating systems for operating and delivery rooms.
8. Supply, return, exhaust ventilating systems and/or air-conditioning systems serving telephone equipment rooms and closets and data equipment rooms and closets *»517.35(A)«*.

Note

Sequential delayed automatic connection to the alternate power source, thereby preventing generator overload, is permitted where engineering studies indicate it is necessary ***»517.35(A) Exception«***.



Nursing Homes and Limited-Care Facilities

Essential Electrical Systems (Greater than 150 kVA)

Nursing homes and other limited care facilities can be classified as Category 1 and/or Category 2 patient care spaces depending on the design and type of care administered in the facility. For Category 1 spaces, see 517.29 through 517.35. For Category 2 spaces not served by Type 1 essential electrical systems, see 517.40 through 517.44 *»517.40 Informational Note No. 1«*.

Ⓐ Essential electrical systems shall have at least two independent power sources. One on-site source (or sets of sources) shall be sized to supply the entire essential electrical system. The other independent source (or sets of sources) shall be sized to supply the entire essential electrical system and shall be permitted to be located on-site or off-site. Additional sources other than the first two independent sources shall be permitted to be sized to supply the intended load *»517.41(A)«*.

Ⓑ Essential electrical system components shall be located to minimize interruptions caused by natural forces common to the area (e.g., storms, floods, earthquakes, or hazards created by adjoining structures or activities) *»517.41(B)«*.

Ⓒ The number of transfer switches used is based on reliability, design, and load considerations. Each essential electrical system branch (life safety and equipment) shall have one or more transfer switches *»517.42(B)«*.

Ⓓ The life safety branch shall be installed and connected to the alternate source of power so that all functions specified herein shall be automatically restored to operation within 10 seconds after the interruption of the normal source. No functions other than those listed in 517.43(A) through (G) shall be connected to the life safety branch *»517.43«*.

Ⓔ The essential electrical system shall be capable of meeting the demand for operation of all functions and equipment being served simultaneously by each branch *»517.42(C)«*.

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Essential Electrical Systems (Greater than 150 kVA) *(continued)*

Ⓕ Essential electrical systems for nursing homes and limited care facilities shall be divided into the following two branches, the life safety branch and the equipment branch. The division between the branches shall occur at transfer switches where more than one transfer switch is required »*517.42(A)*«.

Type 2 essential electrical systems are comprised of two separate branches capable of supplying a limited amount of lighting and power service, which is considered essential for the protection of life and safety and effective operation of the institution during the time normal electrical service is interrupted for any reason »*517.42(A) Informational Note No. 1*«.

Ⓖ The equipment branch shall be installed and connected to the alternate power source so that the equipment described in 517.35(A)(6) shall be automatically restored to operation at appropriate time-lag intervals following the energizing of the life safety and critical branches. The equipment branch arrangement shall also provide for the additional connection of equipment listed in 517.44(B) »*517.44*«.

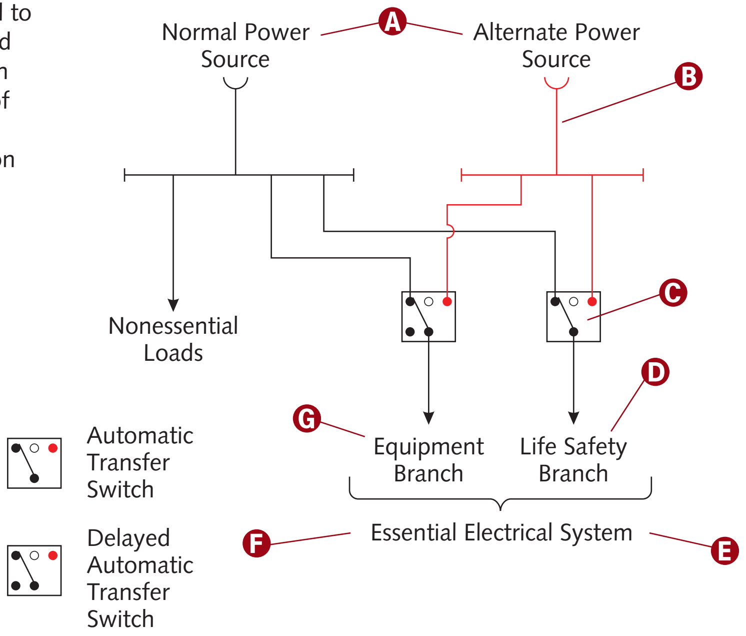
Note

Essential electrical system components shall be located to minimize interruptions caused by natural forces common to the area (such as storms, floods, earthquakes, or hazards created by adjoining structures or activities). Installations of electrical services shall be located to reduce possible interruption of normal electrical services resulting from similar causes as well as possible disruption of normal electrical service due to internal wiring and equipment failures. Feeders shall be located to give physical separation of the feeders of the alternate source and from the feeders of the normal electrical source to prevent possible simultaneous interruption ***»517.41(B)«***.

Warning

The life safety branch and equipment branch shall be entirely independent of all other wiring and equipment. These circuits and shall not enter the same raceways, boxes, or cabinets with other wiring except as follows:

1. In transfer switches,
2. In exit or emergency luminaires supplied from two sources, or
3. In a common junction box attached to exit or emergency luminaires supplied from two sources »*517.42(D)*«.



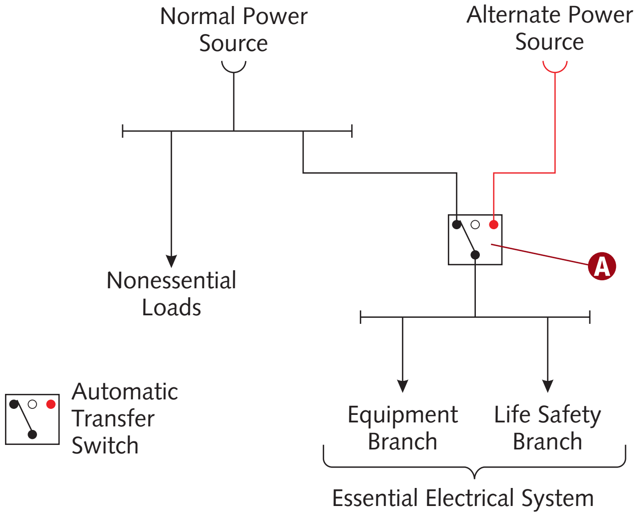
Nursing Home and Limited Health Care Facilities—Minimum Requirement (greater than 150 kVA) for Transfer Switch Arrangement

Essential Electrical Systems (150 kVA or Less)

Ⓐ One transfer switch shall be permitted to serve one or more branches or systems in a facility with a continuous load on the switch of 150 kVA (120 kW) or less »*517.42(B)(2)*«.

Note

For essential electrical systems under 150 kVA, deletion of the time-lag intervals feature for delayed automatic connection to the equipment branch shall be permitted ***»517.44 Exception«***.



Nursing Home and Limited Health Care Facilities—Minimum Requirement (150 kVA or less) for Transfer Switch Arrangement

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Life Safety Branch

A Life safety branch installation and alternate power source connection shall provide that all functions specified in 517.43(A) through (G) are automatically restored to operation within 10 seconds after interruption of the normal source. The life safety branch shall supply power for the following lighting, receptacles, and equipment »*517.43*«.

B Illumination of means of egress as is necessary for corridors, passageways, stairways, landings, and exit doors and all ways of approach to exits shall be connected to the critical branch. Patient corridor lighting can be transferred via switching arrangement from general illumination circuits, provided only one circuit can be selected and both circuits cannot be simultaneously extinguished »*517.43(A)*«.

C Task illumination and selected receptacles at the generator set location and essential electrical system transfer switch locations shall be connected to the life safety branch »*517.43(E)*«.

D Generator accessories, including, but not limited to, the transfer fuel pump, electrically operated louvers, and other generator accessories essential for generator operation, shall be arranged for automatic connection to the alternate power source and connected to the life safety branch »*517.43(G)*«.

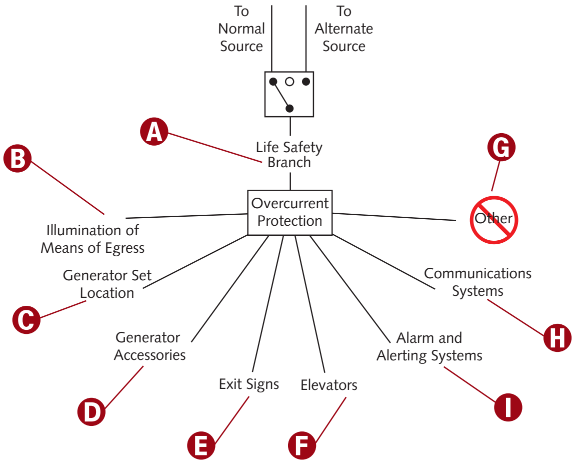
E Exit and exit directional signs shall be connected to the life safety branch »*517.43(B)*«.

F Elevator cab lighting, control, communications, and signal systems shall be connected to the life safety branch »*517.43(F)*«.

G Connect only those functions listed in 517.43(A) through (G) to the life safety branch »*517.43*«.

H Communications systems used for issuing emergency condition instructions shall be connected to the life safety branch »*517.43(D)*«.

I Alarm and alerting systems including the following shall be connected to the life safety branch: (1) fire alarms and (2) alarms required for systems piping of nonflammable medical gases »*517.43(C)*«.



Equipment Branch

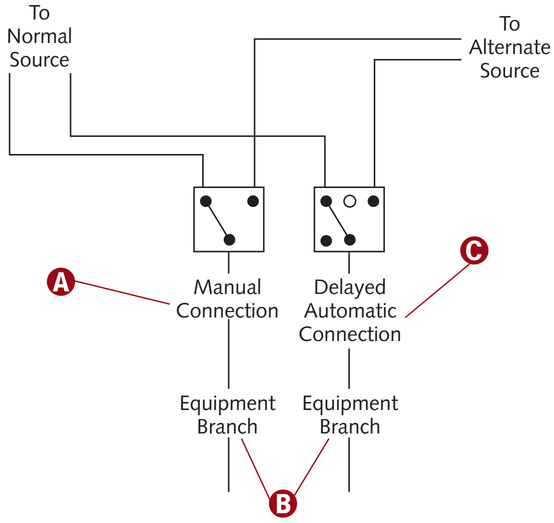
A The following equipment shall be permitted to be connected to the equipment branch and shall be arranged for either delayed automatic or manual connection to the alternate power source:

1. Heating equipment providing patient room heating.
2. Elevator service where power disruption would result in between-floor stops. Throw-over facilities shall be provided to allow temporary operation of any elevator passenger release. See 517.43(F) for elevator cab lighting, control, and signal system requirements.
3. Additional illumination, receptacles, and equipment can be connected only to the equipment branch.
4. Where one switch serves multiple systems as permitted in 517.43, transfer for all loads shall be nondelayed automatic. »*517.44(B)*«.

B The equipment branch shall be installed and connected to the alternate power source so that equipment listed in 517.35(A)(6) is automatically restored to operation at appropriate time-lag intervals following the energizing of the life safety and critical branches. Arrangement shall also provide for additional connection of equipment listed in 517.44(B), by either delayed automatic or manual operation »*517.44*«.

C The following equipment shall be permitted to be connected to the equipment branch and shall be arranged for delayed automatic connection to the alternate power source:

1. Task illumination and selected receptacles in the following: (a) patient care spaces; (b) medication preparation spaces; (c) pharmacy dispensing areas; and (d) nurses' stations (unless adequately lighted by corridor luminaires)
2. Supply, return, and exhaust ventilating systems for airborne infectious isolation rooms
3. Sump pumps and other equipment required to operate for the safety of major apparatus and associated control systems and alarms
4. Smoke control and stair pressurization systems
5. Kitchen hood supply or exhaust systems, or both, if required to operate during a fire in or under the hood
6. Nurse call systems »*517.44(A)*«



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Inhalation Anesthetizing Locations

Hazardous (Classified) Anesthetizing Locations

Anesthetizing Location: Any space within a facility that has been designated for the administration of any flammable or nonflammable inhalation anesthetic agent (during examination or treatment), including the use of such agents for relative analgesia » *Article 100* «.

Flammable Anesthetics: Gases or vapors, such as fluroxene, cyclopropane, divinyl ether, ethyl chloride, ethyl ether, and ethylene, which may form flammable or explosive mixtures with air, oxygen, or reducing gases such as nitrous oxide » *Article 100* «.

Flammable Anesthetizing Location: Any area of the facility that has been designated to be used for the administration of any flammable inhalation anesthetic agents in the normal course of examination or treatment » *Article 100* «.

Unless otherwise allowed by 517.160, each power circuit within (or partially within) a flammable anesthetizing location (517.60) shall be isolated from any distribution system by means of an isolated power system » *517.61(A)(1)* «.

Any inhalation anesthetizing location designated for the exclusive use of nonflammable anesthetizing agents is considered to be an unclassified location » *517.60(B)* «. Unclassified anesthetizing locations must comply with 517.61(C).

Where an isolated power system is utilized, the isolated power equipment shall be listed as isolated power equipment, and the isolated power system shall be designed and installed in accordance with 517.160 » *517.61(A)(2)* «.

In hazardous (classified) locations referenced in 517.60, all fixed wiring/equipment and all portable equipment (including lamps and other utilization equipment) operating at more than 10 volts between conductors shall comply with the requirements of 501.1 through 501.25, 501.100 through 501.150, and 501.30(A) and (B) for Class I, Division 1 locations. All such equipment shall be approved for the specific hazardous atmosphere involved » *517.61(A)(3)* «.

If a box, fitting, or enclosure is only partially within a hazardous (classified) location(s), the hazardous area extends to include the entire box, fitting, or enclosure » *517.61(A)(4)* «.

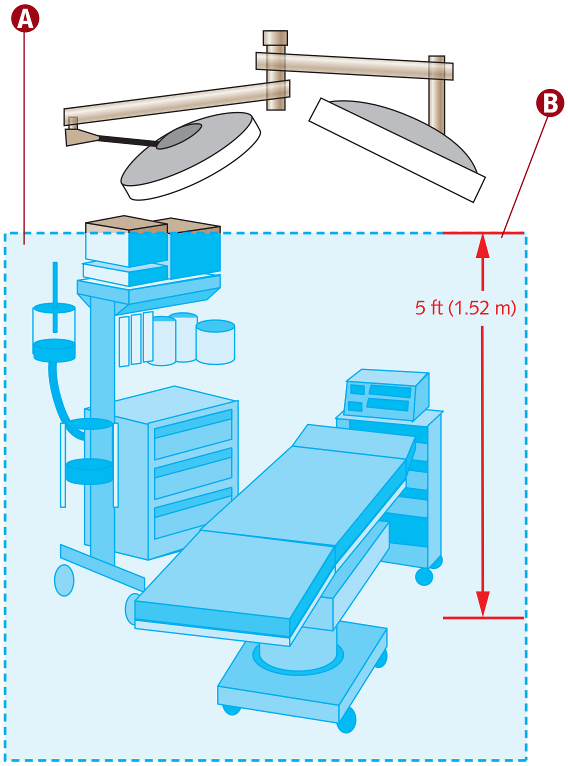
Receptacles and attachment plugs in a hazardous (classified) location(s) shall be listed for use in Class I, Group C hazardous (classified) locations and shall provide a grounding conductor connection » *517.61(A)(5)* «.

Flexible cords used in hazardous (classified) locations for connection of portable utilization equipment (including lamps operating at more than 8 volts between conductors) shall be of a type approved for extra-hard usage per Table 400.4 and shall include an additional conductor for grounding » *517.61(A)(6)* «.

The flexible cord shall include a storage device that does not subject the cord to less than a 3-in. (75-mm) bending radius » *517.61(A)(7)* «.

Ⓐ Any room (or location) storing flammable anesthetics or volatile flammable disinfecting agents is a Class I, Division 1 location from floor to ceiling » *517.60(A)(2)* «.

Ⓑ Wherever flammable anesthetics are employed, the entire area is a Class I, Division 1 location, extending from the floor upward to a level of 5 ft (1.52 m). The remaining space (up to the structural ceiling) is considered to be above a hazardous (classified) location » *517.60(A)(1)* «.



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Above Hazardous (Classified) Anesthetizing Locations

Wiring above a hazardous (classified) location (referenced in 517.60) shall be installed in RMC, EMT, IMC, Type MI cable, or Type MC cable employing a continuous gas/vaportight metal sheath »*517.61(B)(1)*«.

Installed equipment that may produce arcs, sparks, or particles of hot metal (such as lamps and lampholders for fixed lighting, cutouts, switches, generators, motors, or other equipment having make-or-break or sliding contacts) shall be of the totally enclosed type, or by design shall prevent the escape of sparks or hot metal particles »*517.61(B)(2)*«. Wall-mounted receptacles installed above the hazardous (classified) location in flammable anesthetizing locations require neither total enclosure nor guarded or screened openings to prevent particle dispersion »*517.61(B)(2) Exception*«.

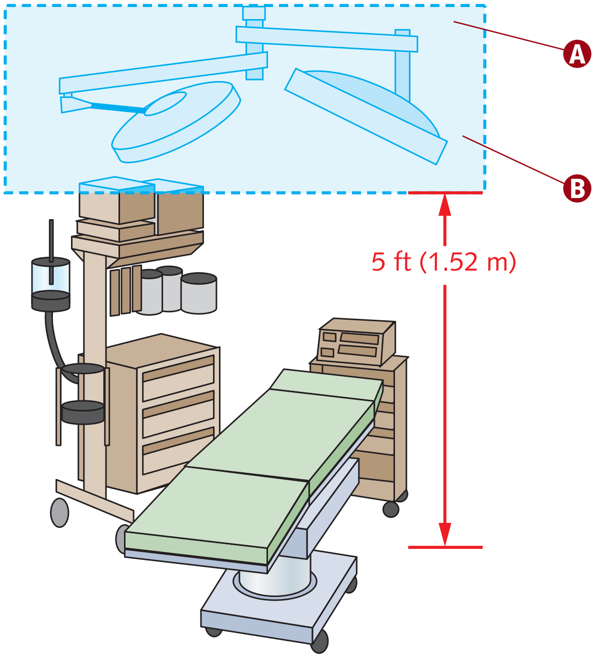
Listed seals shall be provided in conformance with 501.15. Section 501.15(A)(4) applies to both horizontal and to vertical boundaries of the defined hazardous (classified) locations »*517.61(B)(4)*«.

Receptacles and attachment plugs located above hazardous (classified) anesthetizing locations shall be listed for hospital use for services of prescribed voltage, frequency, rating, and number of conductors with provision for the connection of the grounding conductor. This requirement applies to attachment plugs and receptacles of the 2-pole, 3-wire grounding type for single-phase, 120-volt, nominal, ac service »*517.61(B)(5)*«.

Plugs and receptacles rated 250 volts for connection of 50- and 60-ampere ac medical equipment above hazardous (classified) locations shall be arranged so that the 60-ampere receptacle accepts either the 50- or 60-ampere plug. Fifty-ampere receptacles shall *not* accept a 60-ampere attachment plug. The plugs shall be on the 2-pole, 3-wire design, with a third contact connecting to the insulated (green or green with yellow stripe) electrical system equipment grounding conductor »*517.61(B)(6)*«.

A Wiring above a hazardous (classified) location must meet 517.61(B)(1) through (6) provisions.

B Surgical and other luminaires shall conform to 501.130(B) »*517.61(B)(3)*«.



Diagnostic Imaging and Treatment Installations

Mobile, Portable, and Transportable Diagnostic Imaging and Treatment Equipment

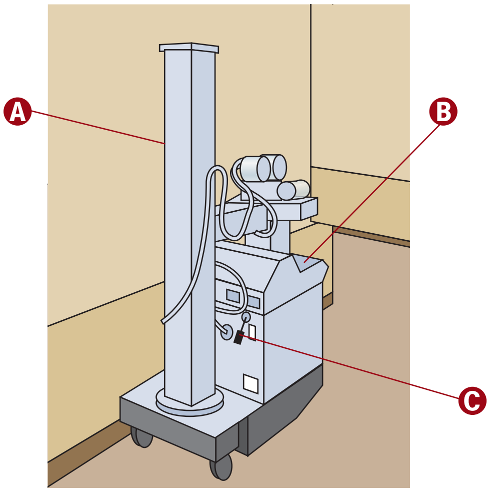
A **Mobile:** X-ray equipment mounted on a permanent base with wheels, casters, or a combination of both, facilitating movement of equipment while fully assembled »*Article 100*«.

Portable: X-ray equipment designed to be hand-carried »*Article 100*«.

Transportable: X-ray equipment to be conveyed by a vehicle or that is readily disassembled for transport by a vehicle »*Article 100*«.

B Individual branch circuits are not required for portable, mobile, and transportable medical diagnostic imaging and treatment equipment requiring a capacity of 60 amperes or less »*517.71(B)*«.

C For portable diagnostic imaging and treatment equipment connected to a 120-volt branch circuit of 30 amperes (or less), a properly rated grounding-type attachment plug and receptacle can serve as a disconnecting means »*517.72(C)*«.



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Fixed and Stationary Diagnostic Imaging and Treatment Equipment

Fixed and stationary diagnostic imaging and treatment equipment shall be connected to the power supply by means of a wiring method complying with applicable requirement, of Chapters 1 through 4 of the *NEC*, as modified by Article 517 »*517.71(A)*«. Equipment properly supplied by a branch circuit rated at 30 amperes (or less) can be supplied through a suitable attachment plug and hard-service cable (or cord) »*517.71(A) Exception*«.

A disconnecting means of adequate capacity for at least 50% of the input (for momentary rating) or 100% of the input (for long-time rating) of the diagnostic imaging and treatment equipment, whichever is greater, shall be provided »*517.72(A)*«.

The disconnecting means shall be operable from a location readily accessible from the control location »*517.72(B)*«.

Momentary rating: a rating based on an operating interval of 5 seconds or less »*Article 100*«.

Long-time rating: a rating based on an operating interval of 5 minutes or longer »*Article 100*«.

Supply branch-circuit conductor ampacity and the current rating of overcurrent protective devices shall not be less than 50% of the momentary rating or 100% of the long-time rating, whichever is greater »*517.73(A)*«.

Supply feeder ampacity and the current rating of overcurrent protective devices supplying multiple branch circuits feeding diagnostic imaging and treatment equipment shall not be less than 50% of the largest unit's momentary demand rating, plus 25% of the momentary demand rating of the next largest unit, plus 10% of the momentary demand rating of each additional unit »*517.73(B)*«.

The minimum conductor size for branch and feeder circuits is also governed by voltage regulation requirements. For a specific installation, the manufacturer typically specifies minimum distribution transformer and conductor sizes, disconnecting means rating, and overcurrent protection »*517.73(B) Informational Note No. 1*«.

Transformers and capacitors that are part of diagnostic imaging and treatment equipment shall not be required to comply with Parts I and II of Articles 450 and 460. Capacitors shall be mounted within enclosures of insulating material or grounded metal »*517.76*«.

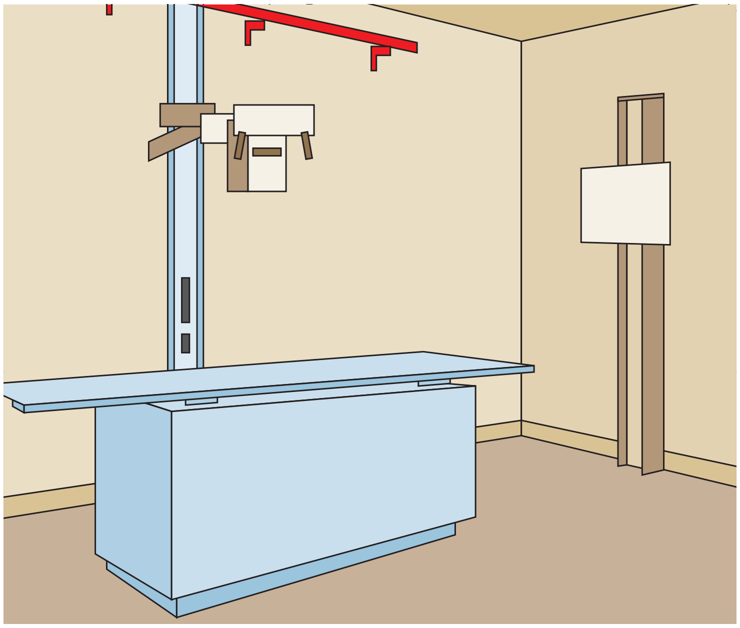
Circuits and equipment operated on a supply circuit of over 1000 volts shall comply with Parts I through IV of Article 495 »*517.71(C)*«.

Note

Non-current-carrying metal parts of diagnostic imaging and treatment and associated equipment (controls, tables, transformer tanks, shielded cables, etc.) shall be connected to an equipment grounding conductor in the manner specified in Part VII of Article 250, as modified by 517.13(A) and (B) »*517.78(C)*«.

Warning

Do not construe anything in Article 517, Part V as specifying safeguards against possible radiation or magnetic fields »*517.70*«. (See Informational Notes 1 and 2 for information pertaining to safety and performance.)



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Summary

- Article 517 provisions apply to electrical construction and installation criteria in health care facilities that provide services to human beings.
- Many commonly used health care facility terms are defined in Article 100.
- Article 517's installation criteria and wiring methods serve to minimize electrical hazards.
- Nursing homes and limited-care facilities share the same provisions, found in 517.40 through 517.44.
- Each patient bed location, in Category 2 spaces, shall have at least eight receptacles.
- Within Category 1 spaces, each patient bed location requires a minimum of fourteen receptacles.
- The required receptacles in both general and critical care spaces can be of the single, duplex, or quadruplex types or any combination of the three.
- An isolated ground receptacle shall not be installed within a patient care vicinity.
- Receptacles that are located within the patient rooms, bathrooms, playrooms, and activity rooms of pediatric units, other than nurseries, shall be listed tamper-resistant or shall employ a listed tamper-resistant cover.
- Essential electrical systems for hospitals shall be comprised of three separate branches: life safety branch, critical branch, and equipment branch.
- Essential electrical systems shall have a minimum of two independent sources of power: a normal source generally supplying the entire electrical system and one or more alternate source(s) for use when the normal source is interrupted.
- Essential electrical systems for nursing homes and limited-care facilities are composed of two separate branches: the life safety branch and the equipment branch.
- The entire area surrounding any location employing flammable anesthetics is a Class I, Division 1 location, including the area extending upward from the floor to a level of 5 ft (1.52 m).
- Wiring and equipment within anesthetizing locations must comply with 517.61 requirements.
- Diagnostic imaging and treatment installations must comply with 517, Part V requirements.
- Each operating room shall be provided with a minimum of thirty-six receptacles.

Unit 16 Competency Test

NEC® Reference	Answer	
____________	____________	1. Low-voltage cables for diagnostic imaging and treatment equipment connecting to oil-filled units that are not completely sealed, such as transformers, condensers, oil coolers, and high-voltage switches, shall have insulation of the ____________ type.
____________	____________	2. The life safety and critical branches shall be installed and connected to the alternate power source so that all functions specified herein for the life safety and critical branches are automatically restored to operation within ____________ after interruption of the normal source.
____________	____________	3. The equipment-grounding terminal buses of the normal and essential branch-circuit panelboards serving the same individual patient care vicinity shall be connected together with an insulated continuous copper conductor not smaller than ____________.
____________	____________	4. The ____________ is a system of feeders and branch circuits supplying power for task illumination, fixed equipment, select receptacles, and select power circuits serving areas and functions related to patient care and that are automatically connected to alternate power sources by one or more transfer switches during interruption of the normal power source.
____________	____________	5. The cover plates for the electrical receptacles supplied from the life safety and critical branches shall have a distinctive ____________ so as to be readily identifiable.
____________	____________	6. ____________ is a jack or terminal that serves as the collection point for redundant grounding of electric appliances serving a patient care vicinity or for grounding other items in order to eliminate electromagnetic interference problems.

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***NEC*® Reference** **Answer**

____________ ____________ 7. In any anesthetizing area, all metal raceways and metal-sheathed cables, and all normally non-current-carrying conductive portions of fixed electric equipment, shall be ___________.

____________ ____________ 8. A disconnecting means rated for at least ___________% of the input required for the momentary rating or ___________% of the input required for the long-time rating of the diagnostic imaging and treatment equipment, whichever is greater, shall be provided in the supply circuit.

____________ ____________ 9. Each patient bed location in a Category 1 space shall be supplied by at least ___________ branch circuit(s).

____________ ____________ 10. A patient care vicinity is defined as a space, within a location intended for the examination and treatment of patients, extending ___________ ft beyond the normal location of the patient bed, chair, table, treadmill, or other device that supports the patient during examination and treatment and extending vertically to ___________ ft above the floor.

____________ ____________ 11. The line isolation monitor for an isolated power system in a health care facility shall not alarm for a fault hazard of less than ___________ mA or for a total hazard current of less than ___________ mA.

____________ ____________ 12. Receptacles that are located within patient rooms, bathrooms, playrooms, and activity rooms of pediatric units or spaces with similar risk as determined by the health care facility's governing body by conducting a risk assessment, other than infant nurseries, shall be ___________ or shall employ a ___________ cover.

____________ ____________ 13. Category ___________ space is space in which failure of equipment or a system is likely to cause minor injury to patients, staff, or visitors.

____________ ____________ 14. In locations where flammable anesthetics are employed, the entire area shall be considered to be a Class I, Division 1 location that shall extend upward to a level ___________ ft above the floor.

____________ ____________ 15. In health care facilities with Category 1 spaces, separation of ground-fault protection time-current characteristics shall conform to the manufacturer's recommendations and shall consider all required tolerances and disconnect operating time to achieve ___________ selectivity.

____________ ____________ 16. For portable diagnostic imaging and treatment equipment connected to a 120-volt branch circuit of ___________ or less, a grounding-type attachment plug and receptacle of proper rating shall be permitted to serve as a disconnecting means.

____________ ____________ 17. The ___________ is a system of feeders and branch circuits supplying power for lighting, receptacles, and equipment essential for life safety that is automatically connected to alternate power sources by one or more transfer switches during interruption of the normal power source.

____________ ____________ 18. A(n) ___________ is used to provide simultaneous service (or treatment) to four or more patients that provides, on an outpatient basis, treatment for patients that renders the patients incapable of taking action for self-preservation under emergency conditions without the assistance of others.

____________ ____________ 19. A(n) ___________ is any area of the health care facility that has been designated to be used for the administration of any flammable inhalation anesthetic agents in the normal course of examination or treatment.

____________ ____________ 20. Each patient bed location in a Category 1 space shall be provided with a minimum of ___________ receptacle(s).

____________ ____________ 21. In patient care spaces, all non-current-carrying conductive surfaces of fixed electrical equipment likely to become energized that are subject to personal contact, operating at over ___________, shall be directly connected to an insulated copper equipment grounding conductor that is clearly identified along its entire length by green insulation.

***NEC*® Reference** **Answer**

____________ ____________ 22. Wall-mounted remote-control stations for remote-control switches operating at ____________ or less shall be permitted to be installed in any anesthetizing location of a health care facility.

____________ ____________ 23. A(n) ____________ is a system comprised of alternate sources of power and all connected distribution systems and ancillary equipment, designed to ensure continuity of electrical power to designated areas and functions of a health care facility during disruption of normal power sources, and also designed to minimize disruption within the internal wiring system.

____________ ____________ 24. In Category 1 spaces, a patient care vicinity shall be permitted to have a patient equipment grounding point. An equipment-bonding jumper, not smaller than ____________, shall be used to connect the grounding terminal of all grounding-type receptacles to the patient equipment grounding point.

____________ ____________ 25. Individual branch circuits shall not be required for portable, mobile, and transportable medical diagnostic imaging and treatment equipment requiring a capacity of not over ____________.

____________ ____________ 26. Each Category 2 space patient bed location shall be provided with a minimum of ____________ receptacle(s).

____________ ____________ 27. Category ____________ space is space in which failure of equipment or a system is likely to cause major injury or death to patients, staff, or visitors.

____________ ____________ 28. One transfer switch shall be permitted to serve one or more branches or systems in a limited care facility with a continuous load on the switch of ____________ kVA (____________ kW) or less.

____________ ____________ 29. Size 18 or 16 AWG fixture wires as specified in 724.49 and flexible cords shall be permitted for the control and operating circuits of diagnostic imaging and treatment equipment and auxiliary equipment where protected by not larger than ____________-ampere overcurrent devices.

____________ ____________ 30. A flexible cord storage device, within a hazardous (classified) anesthetizing location in a health care facility, shall not subject the cord to bending at a radius of less than ____________ in.

____________ ____________ 31. All branch circuits serving patient care spaces in health care facilities shall be provided with an effective ____________ path by installation in a metal raceway system or a cable having a metallic armor or sheath assembly.

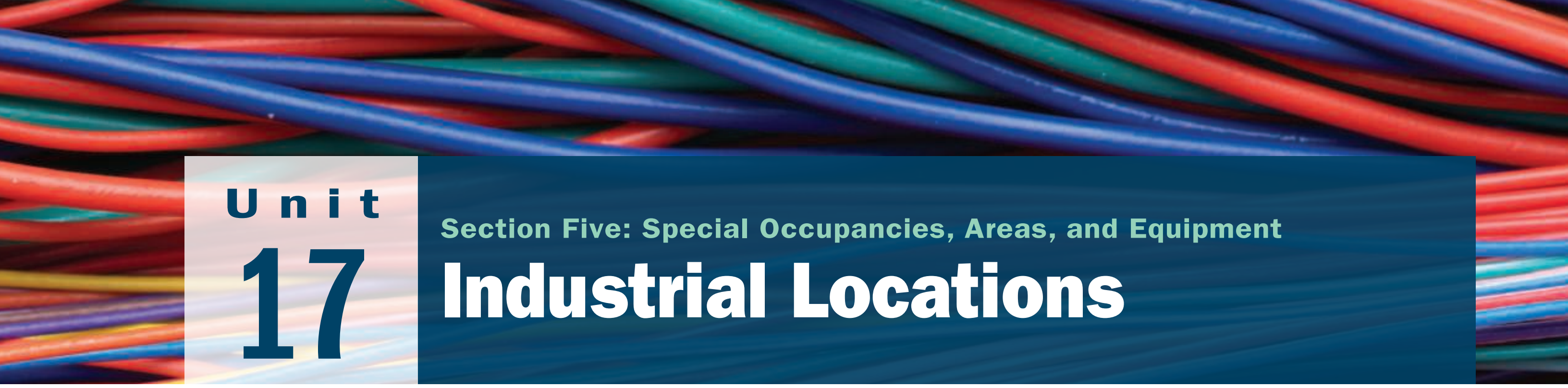
____________ ____________ 32. Type 2 essential electrical systems for nursing homes and limited care facilities shall be divided into the following two branches, the ____________ branch and the ____________ branch.

____________ ____________ 33. The ampacity of supply branch-circuit conductors and the current rating of overcurrent protective devices for diagnostic imaging and treatment equipment shall not be less than ____________% of the momentary rating or ____________% of the long-time rating, whichever is greater.

____________ ____________ 34. In Category 1 spaces, the equipment grounding conductor for special-purpose receptacles, such as the operation of mobile X-ray equipment, shall be extended to the ____________ of branch circuits for all locations likely to be served from such receptacles.

____________ ____________ 35. ____________ is the area in a patient care space where a procedure is performed that is normally subject to wet conditions while patients are present, including standing fluids on the floor or drenching of the work area, either of which condition is intimate to the patient or staff.

____________ ____________ 36. Each operating room shall be provided with a minimum of ____________ receptacles.



Unit 17

Section Five: Special Occupancies, Areas, and Equipment

Industrial Locations

Objectives

After studying this unit, the student should be able to:

- summarize service entrance provisions with or without a single main disconnecting means.
- recall that a raceway (or cable) shall not contain both service conductors and nonservice conductors.
- clarify feeder tap rules.
- describe the provisions pertaining to transformer secondary conductors.
- summarize transformer vault provisions.
- size a common grounding electrode conductor and grounding electrode conductors taps.
- size supply-side bonding jumpers by two different methods when the service conductors are connected in parallel and installed in different raceways.
- recall the provision requiring a full size equipment grounding conductor (when used) in each paralleled raceway.
- explain in detail cable tray provisions.
- explain both general and specific motor provisions, that is, motor and branch-circuit overload protection, branch-circuit conductors, branch-circuit protection, feeder conductors, feeder protection, etc.
- summarize specific equipment provisions for cranes and hoists, electric welders, electroplating equipment, industrial machinery, and capacitors.
- explain when and how to install a grounding (and bonding) terminal bar in a dry-type transformer.

Introduction

Because industrial wiring covers such a broad spectrum of electrical applications, one unit simply cannot contain all of the related provisions. As with other topics, this text's building-block approach has laid the foundation for industrial locations, and it has steadily built upon that foundation with layers of additional information. For instance, previous units address items pertinent to industrial projects, such as raceways, services, clearances, busways, transformers, etc. Provisions for services and service equipment can be found in Units 9, 10, and 14, as well as here (as they apply more specifically to industrial applications).

In particular, this unit explains various feeder tap installation provisions, as found in 240.21. These include, among others, the 10-ft (3.0-m) and 25-ft (7.5-m) tap rules, plus transformer secondary conductor rules. While general transformer provisions were introduced in Unit 14, this unit expands that topic by discussing transformer vault requirements. Grounding and bonding provisions make up a part of this unit. Included are grounding electrode conductor taps, bonding service raceways, and equipment grounding conductors in paralleled raceways. Cable tray requirements are also addressed in this unit. Cable tray installations, of course, are not limited to industrial environments. They are often part of commercial projects and are used in many other areas as well.

Article 430 (Motors, Motor Circuits, and Controllers) applies a great number of requirements to the installation of motors, motor branch-circuit and feeder conductors and their protection, motor overload protection, motor-control circuits, motor controllers, and motor-control centers. The most commonly used of these provisions are illustrated and explained within this unit. Finally, specific equipment typically found in industrial-type locations is presented. Such specific equipment includes cranes and hoists, electric welders, electroplating equipment, industrial machinery, and capacitors.

The aim of this unit is to introduce, in a broad manner, the more common components of a very complex area. See Delmar Cengage Learning's extensive list of offerings for a more in-depth study of industrial electrical wiring.

General

Service Entrance: One Main Disconnect

Where an orderly shutdown is required to minimize the personnel/equipment hazard(s), a system of coordination based on the following two conditions is permitted: (1) coordinated short-circuit protection and (2) overload indication based on monitoring systems or devices »*240.12*«.

Knife switches rated more than 1200 amperes at 250 volts or less, and at over 1000 amperes at 251 to 1000 volts, shall be used only as isolating switches and shall not be opened under load »*404.13(A)*«.

Use a circuit breaker or a switch listed for such purpose to interrupt currents over 1200 amperes at 250 volts, nominal, or less; or, over 600 amperes at 251 to 1000 volts, nominal »*404.13(B)*«.

Ⓐ The next higher standard overcurrent device rating (above the ampacity of the conductors being protected) is permitted, provided all the following conditions are met.

1. The protected conductors are not part of a branch circuit supplying more than one receptacle for cord- and plug-connected portable loads.
2. The conductors' ampacity does not correspond with a fuse/circuit breaker's standard ampere rating without overload trip adjustments above its rating (but it can have other trip or rating adjustments).
3. The next higher standard rating does not exceed 800 amperes »*240.4(B)*«.

Ⓑ Service equipment rated no more than 1000 volts shall be marked to identify it as being suitable for use as service equipment »*230.66(A)*«.

Ⓒ Each ungrounded circuit conductor shall have overcurrent protection located at the point where the conductors receive their supply, except as specified in 240.21(A) through (H) »*240.21*«.

Ⓓ The number of disconnects on the load side of the service disconnecting means is not limited to six.

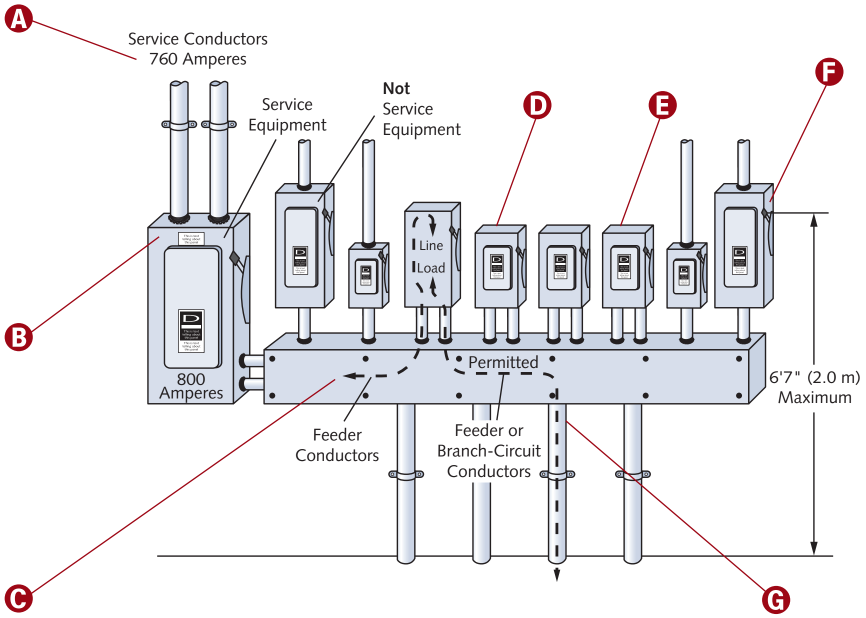
Ⓔ Cartridge fuse and fuseholder overcurrent protection provisions are located in 240.60 through 240.67.

Ⓕ All switches, and circuit breakers used as switches, shall be located in a readily accessible and operable place. The center of the switch (or circuit breaker) operating handle's grip in its highest position shall not be more than 6 ft 7 in. (2.0 m) above the floor/working platform »*404.8(A)*«.

Ⓖ Where insulated conductors are deflected within a metal wireway, either at the ends or where conduits, fittings, or other raceways or cables enter or leave the metal wireway, or where the direction of the metal wireway is deflected greater than 30 degrees, dimensions corresponding to one wire per terminal in Table 312.6(A) shall apply »*376.23(A)*«.

Note

See this book's Units 8 and 14 for electrical equipment working space clearances as specified in 110.26.



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Service Entrance: Six Separate Disconnects

Means shall be provided to disconnect all conductors in a building (or other structure) from the service-entrance conductors »*230.70*«.

Install the service disconnecting means at a readily accessible location, either outside of a building/structure or inside nearest the service conductors' entry point »*230.70(A)(1)*«.

A set of fuses is considered all the fuses required to protect all of the circuit's ungrounded conductors »*230.90(A)*«.

A Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

(1) separate enclosures with a main service disconnecting means in each enclosure;

(2) panelboards with a main service disconnecting means in each panelboard enclosure;

(3) switchboard(s) where there is only one service disconnect in each separate vertical section with barriers separating each vertical section;

(4) service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment.

(5) metering centers with a main service disconnecting means in each metering center; or

(6) motor control center(s) with only one service disconnect in each motor control center unit and not more than two service disconnects in a single motor control center with barriers provided between each compartment containing a service disconnecting means »*230.71(B)*«.

B Two to six disconnects, permitted by 230.71, shall be grouped »*230.72(A)*«.

C Two to six circuit breakers (or sets of fuses) can serve as the overcurrent device providing overload protection. The sum of the circuit breakers' or fuses' ratings can exceed the service conductor's ampacity, provided the calculated load (according to Article 220) does not exceed the ampacity of the service conductors »*230.90(A) Exception No. 3*«.

D Each service disconnect shall be permanently marked to identify it as a service disconnect »*230.70(B)*«.

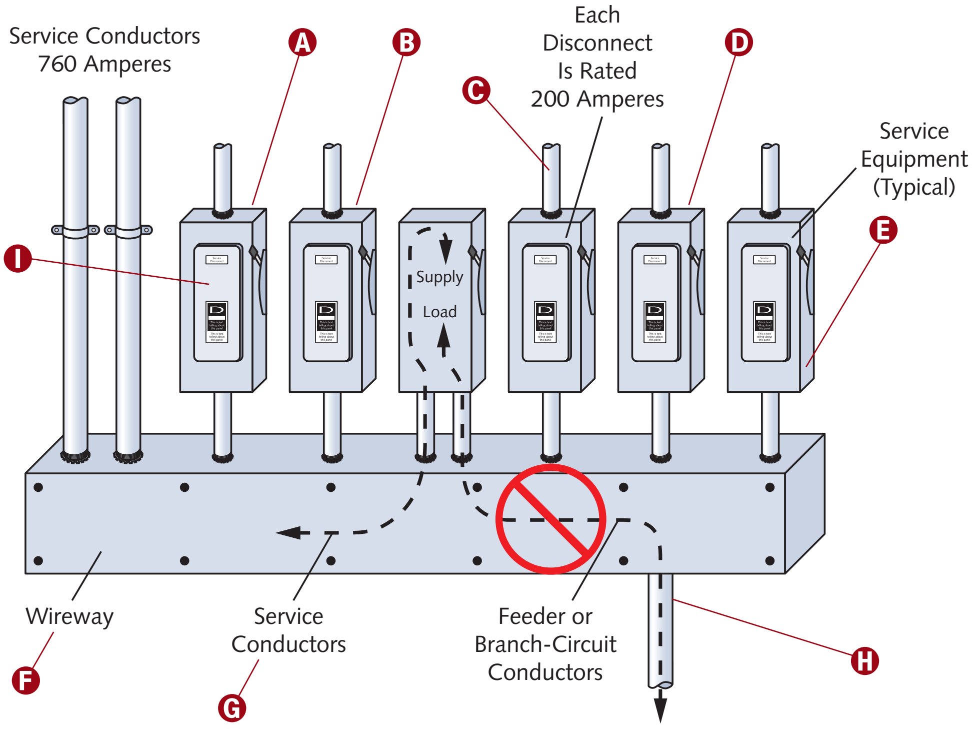
E Where two to six separately enclosed service disconnecting means (supplying separate loads from one service drop, set of overhead service conductors, set of underground service conductors, or service lateral) are grouped at one location, one set of service-entrance conductors can supply each, or several such, service equipment enclosures »*230.40 Exception No. 2*«.

F Article 376 contains metal wireway provisions.

G Service-entrance conductors can be spliced (or tapped) in accordance with 110.14, 300.5(E), 300.13, and 300.15 »*230.46*«.

H Circuit conductors shall not be installed in the same raceway, cable, handhole enclosure, or underground box as the service conductors »*230.7*«. This provision does not apply to grounding electrode conductors or supply side bonding jumpers or conductors. This provision also does not apply to load management control conductors having overcurrent protection »*230.7 Exceptions No. 1* and *No. 2*«.

I This installation is permitted because there are six separate enclosures with a main service disconnecting means in each enclosure.


Service Conductors 760 Amperes
A
B
C
Each Disconnect Is Rated 200 Amperes
D
Service Equipment (Typical)
E
I
Supply
Load
Wireway
F
Service Conductors
G
Feeder or Branch-Circuit Conductors
H

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Note

Each service disconnect shall simultaneously disconnect all ungrounded service conductors under its control from the premises wiring system »*230.74*«.

Section 230.2 permits one (or more) additional service disconnecting means for fire pumps, emergency systems, and legally required or optional standby services. These additional service disconnecting means shall be installed at a sufficient distance from the normal (one to six) service disconnecting means to minimize the possibility of simultaneous interruption of supply »*230.72(B)*«.

Service Entrance: Switchgear versus Panelboard

Two to six service disconnects shall be permitted for each service permitted by 230.2 or for each set of service-entrance conductors permitted by 230.40, Exception No. 1, 3, 4, or 5. The two to six service disconnecting means shall be permitted to consist of a combination of any of the following:

(1) separate enclosures with a main service disconnecting means in each enclosure;

(2) panelboards with a main service disconnecting means in each panelboard enclosure;

(3) switchboard(s) where there is only one service disconnect in each separate vertical section where there are barriers separating each vertical section;

(4) service disconnects in switchgear or metering centers where each disconnect is located in a separate compartment;

(5) metering centers with a main service disconnecting means in each metering center; or

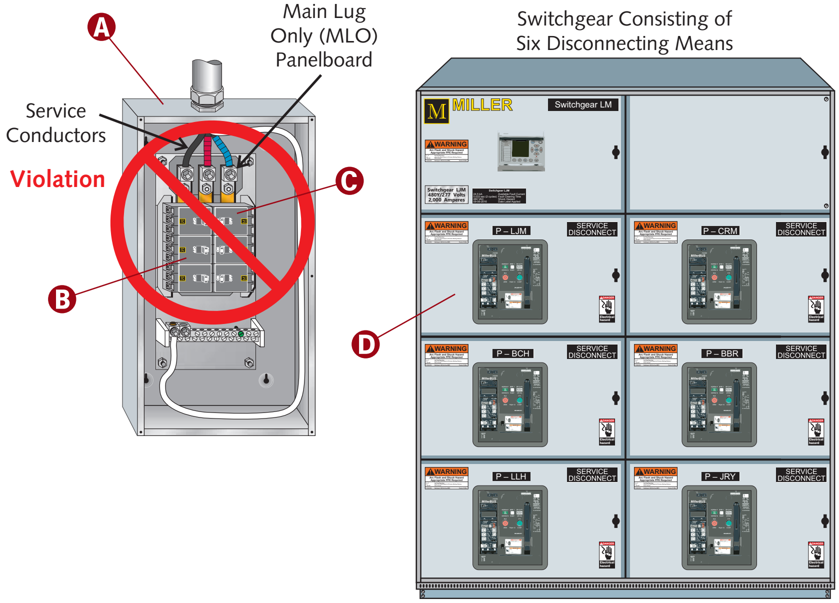
(6) motor control center(s) with only one service disconnect in each motor control center unit and not more than two service disconnects in a single motor control center with barriers provided between each compartment containing a service disconnecting means »*230.71(B)*«.

A Main Lug Only (MLO) Panelboard

B Six circuit breakers mounted in a single enclosure is a violation of 230.71(B)

C Prior to the 2020 edition of the National Electrical Code®, the service disconnecting means was permitted to consist of not more than six switches or sets of circuit breakers, or a combination of not more than six switches and sets of circuit breakers, mounted in a single enclosure. This type of installation is no longer permitted.

D In accordance with 230.71(B), six service disconnects in switchgear where each disconnect is located in a separate compartment is permitted.


A
Main Lug Only (MLO) Panelboard
Service Conductors
Violation
C
B
D
Switchgear Consisting of Six Disconnecting Means
MILLER
Switchgear LM
WARNING
Switchgear LM 480Y/277 Volts 2,000 Amperes
P – LJM
SERVICE DISCONNECT
P – CRM
SERVICE DISCONNECT
P – BCH
SERVICE DISCONNECT
P – BBR
SERVICE DISCONNECT
P – LLH
SERVICE DISCONNECT
P – JRY
SERVICE DISCONNECT

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Feeder Taps

Because of dissimilar metals' characteristics, devices such as pressure terminal/splicing connectors and soldering lugs shall be identified for the conductor's material, shall be properly installed, and shall be properly used. Conductors of dissimilar metals shall not be intermixed in a terminal (or splicing) connector where physical contact occurs between dissimilar conductors (such as copper and aluminum or aluminum and copper-clad aluminum), unless the device is identified for the purpose and conditions of use »*110.14*«.

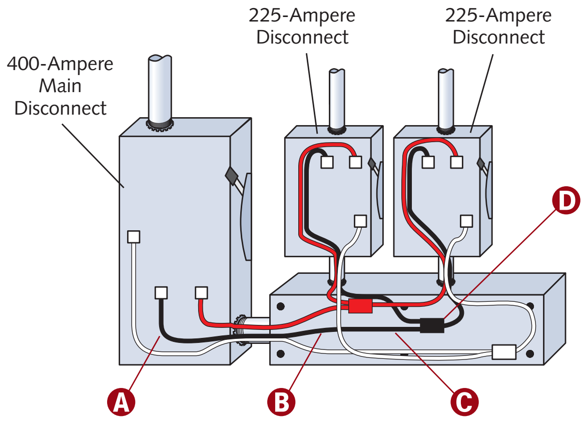
While single-phase system illustrations are used, be aware that the same rules also apply to 3-phase systems.

Ⓐ Tap conductors can be protected against overcurrent in accordance with 210.19(C) and (D), 240.5(B)(2), 240.21, 368.17(B), 368.17(C), and 430.53(D) »*240.4(E)*«.

Ⓑ Conductors can be tapped to a feeder without having overcurrent protection at the tap as specified in 240.21(B)(1) through (5). The provisions of 240.4(B) shall not be permitted for tap conductors »*240.21(B)*«.

Ⓒ Per Article 100, a **tap conductor** is a conductor other than a service conductor having overcurrent protection ahead of its point of supply that exceeds the value permitted for similar conductors protected as otherwise described in 240.4 »*Article 100*«.

Ⓓ All conductor splices, joints, and free ends shall be covered either with an insulation equivalent to that of the conductors or with an identified insulating device »*110.14(B)*«.



10-ft (3.0-m) Feeder Tap Rule

Ⓐ A 60-ampere rated conductor is the minimum size allowed if the overcurrent protection on the tap conductor's line side is 600 amperes (600 ÷ 10 = 60) »*240.21(B)(1)(4)*«.

Ⓑ The tap conductor's ampacity shall not be less than the rating of the equipment containing an overcurrent device(s) supplied by the tap conductors or less than the overcurrent protective device rating at the tap conductor's termination »*240.21(B)(1)(1)(b)*«.

Ⓒ In addition to the requirement of 408.30, a panelboard shall be protected by an overcurrent protective device having a rating not greater than that of the panelboard. This overcurrent protective device shall be located within or at any point on the supply side of the panelboard »*408.36*«.

Ⓓ The tap conductor's ampacity shall not be less than the combined calculated loads on the circuits it supplies »*240.21(B)(1)(1)(a)*«.

Ⓔ The tap conductors shall not extend beyond the switchboard, switchgear, panelboard, disconnecting means, or control devices they supply »*240.21(B)(1)(2)*«.

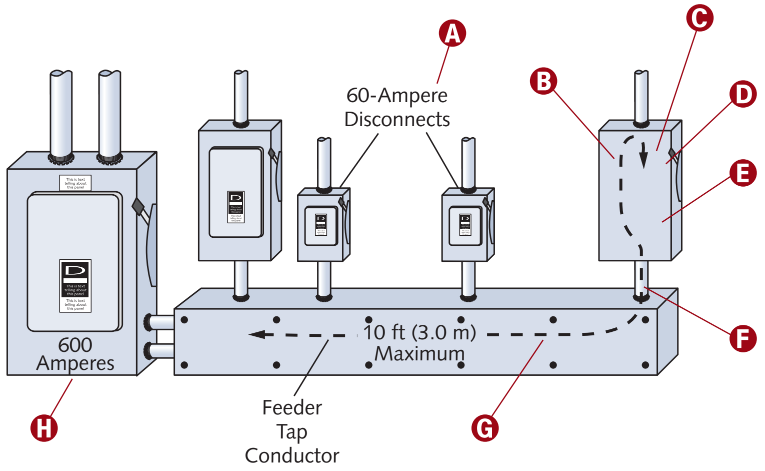
Ⓕ Except where connected to the feeder, tap conductors shall be enclosed in a raceway extending from the tap to the enclosure of an enclosed switchboard, switchgear, panelboard, or control device, or to the back of an open switchboard »*240.21(B)(1)(3)*«.

Ⓖ If the tap conductor's length does not exceed 10 ft (3 m) and all of 240.21(B)(1)(1) through (4) stipulations are satisfied, overcurrent protection at the tap to the feeder is not required »*240.21(B)(1)*«.

Ⓗ Field installations with the tap conductors exiting the enclosure (or vault) where the tap is made require that the ampacity of the tap conductors be not less than one-tenth of the rating of the overcurrent device protecting the feeder conductors »*240.21(B)(1)(4)*«.

Note

Branch-circuit tap conductors meeting the requirements specified in 210.19 shall be permitted to have overcurrent protection as specified in 210.20 »***240.21(A)***«.



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10-ft (3.0-m) Feeder Tap Rule—Example

A parallel set of 500-kcmil THHN feeder conductors will terminate in a metal trough. These feeder conductors will be protected by an 800-ampere overcurrent device. A 30-ampere fused disconnect (with 30 ampere fuses) will be installed to supply a 21-ampere load. The length of the tap conductors will not exceed 10 ft. The tap conductors between the trough and the disconnect will be enclosed in a raceway. All terminations will be rated 75°C. What size tap conductors are required for this installation?

Ⓐ The ampacity of the tap conductors shall not be less than one-tenth of the rating of the overcurrent device protecting the feeder conductors »*240.21(B)(1)(4)*«. The feeder conductors are protected by an 800-ampere overcurrent device.

$$800 \div 10 = 80$$

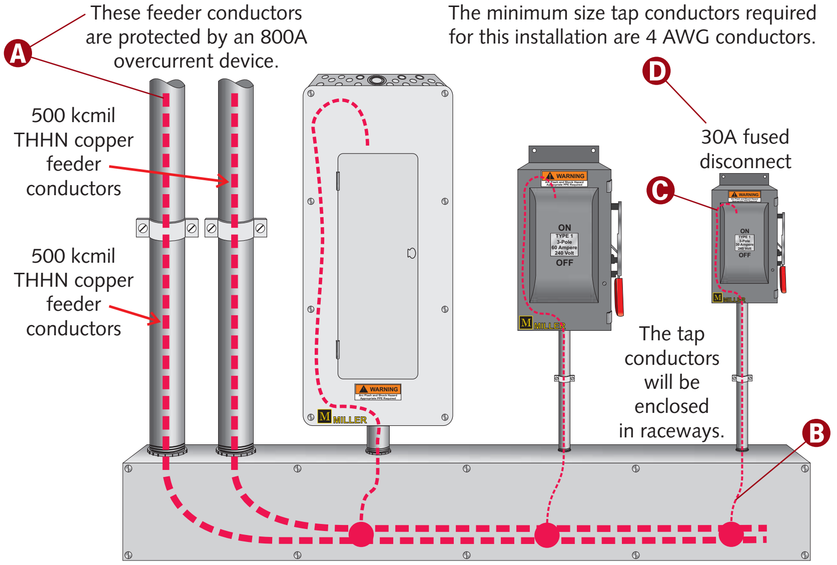
The tap conductors must have a rating of at least 80 amperes.

Ⓑ In accordance with the 75°C column of Table 310.16, the minimum size conductors are 4 AWG copper.

$$\text{4 AWG (in the 75°C column)} = 85\text{A}$$

Ⓒ Although the load is only 21 amperes and the rating of the fused disconnect is 30 amperes, the minimum size tap conductors required for this installation are 4 AWG copper conductors.

Ⓓ While the ampacity of the tap conductors shall not be less than one-tenth the rating of the overcurrent device protecting the feeder conductors, the rating of the overcurrent device can be less than one-tenth the rating of the overcurrent device protecting the feeder conductors.


These feeder conductors are protected by an 800A overcurrent device.
A
The minimum size tap conductors required for this installation are 4 AWG conductors.
D
500 kcmil THHN copper feeder conductors
500 kcmil THHN copper feeder conductors
30A fused disconnect
C
WARNING
ON
OFF
MILLER
The tap conductors will be enclosed in raceways.
B

None of the tap conductors will exceed 10 feet.

25-ft (7.5-m) Feeder Tap Rule

Ⓐ A 200-ampere rated conductor is the minimum size allowed if the overcurrent protection on the tap conductor's line side is 600 amperes (600 ÷ 3 = 200) »*240.21(B)(2)(1)*«.

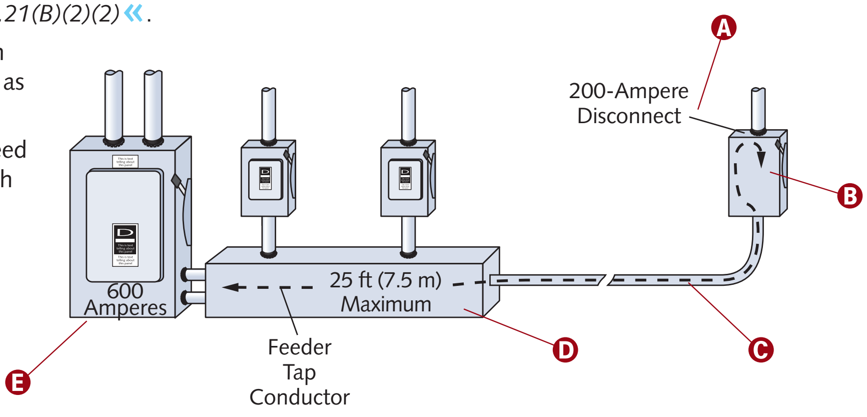
Ⓑ The tap conductors shall terminate in a single circuit breaker (or single set of fuses) that will limit the load of the tap conductor's ampacity. This device can supply unlimited additional load side overcurrent devices »*240.21(B)(2)(2)*«.

Ⓒ The tap conductors shall be protected from physical damage in an approved manner, such as enclosed in a raceway »*240.21(B)(2)(3)*«.

Ⓓ If the tap conductor's length does not exceed 25 ft (7.5 m) and all of 240.21(B)(2)(1) through (3) stipulations are satisfied, overcurrent protection at the tap to the feeder is not required »*240.21(B)(2)*«.

Ⓔ The tap conductors' ampacity shall not be less than one-third of the feeder conductor's overcurrent device rating »*240.21(B)(2)(1)*«.

> **Note**
>
> Tap conductors longer than 25 ft (7.5 m) shall comply with 240.21(B)(4) specifications.


A
200-Ampere Disconnect
B
600 Amperes
25 ft (7.5 m) Maximum
Feeder Tap Conductor
D
C
E

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25-ft (3.0-m) Feeder Tap Rule—Example

500-kcmil THHN copper feeder conductors will terminate in a junction box. The feeder conductors will be protected by a 400-ampere circuit breaker. A main-breaker, 40-circuit panelboard will be installed within 20 ft of the junction box. The main breaker in this panelboard will have a rating of 250 amperes. The conductors supplying this panelboard will be tap conductors because they will be connected in the junction box to the 500 kcmil feeder conductors. The calculated load on this panelboard is 190 amperes. The length of these tap conductors will be more than 10 ft, but not more than 25 ft. The tap conductors between the junction box and panelboard will be enclosed in a raceway. All terminations will be rated 75°C. What size tap conductors are required to supply this panelboard?

Because the length of the tap conductors is more than 10 ft but not more than 25 ft, size the tap conductors in accordance with the 25-ft tap rule in 240.21(B)(2).

Ⓐ To find the minimum size conductor, divide the rating of the overcurrent device protecting the feeder conductors by 3.

$$400 \div 3 = 133$$

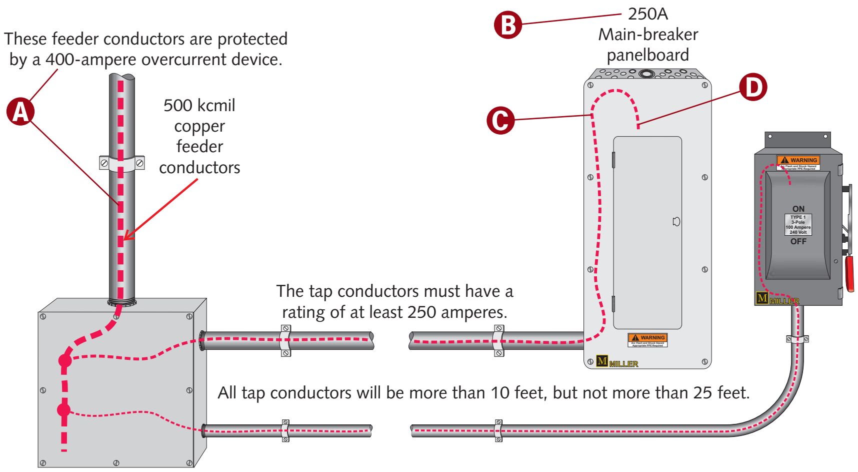
The tap conductors must have a rating of at least 133 amperes.

Ⓑ Because the main breaker in the panelboard will be rated 250 amperes, the tap conductors will have an ampacity that will be more than the minimum 133 amperes.

Ⓒ Because this is a feeder tap, it is not permissible to use the round-up rule. The ampacity rating of the tap conductors shall not be less than the ampacity rating of the main breaker in the panelboard. The ampacity rating of the main breaker in the panelboard is 250 amperes. The conductors supplying the panelboard shall have an ampacity of at least 250 amperes. Find a conductor with an ampacity of at least 250 amperes in Table 310.16.

250 kcmil (in the 75°C column) = 255A

Ⓓ The ampacity of the tap conductors must not be less than the rating of the overcurrent protective device at the termination of the tap conductors »*240.21(B)(2)(2)*«.


These feeder conductors are protected by a 400-ampere overcurrent device.
A
500 kcmil copper feeder conductors
B
250A Main-breaker panelboard
C
D
WARNING
ON
OFF
MILLER
The tap conductors must have a rating of at least 250 amperes.
All tap conductors will be more than 10 feet, but not more than 25 feet.

Tap Rule for High-Bay Manufacturing Building

The fourth feeder tap rule in 240.21(B) can only be utilized under specific parameters and only when installed in a high-bay manufacturing building.

Feeder taps over 25 ft (7.5 m) long, installed in a high-bay manufacturing building must comply with all the conditions in 240.21(B)(4)(1) through (9).

Ⓐ The height of the walls in the high-bay manufacturing building must be over 35 ft (11 m) high »*240.21(B)(4)*«.

Ⓑ The tap conductors shall not be over 25 ft (7.5 m) long horizontally »*240.21(B)(4)(2)*«.

Ⓒ The total length of the tap conductors shall not be over 100 ft (30 m) »*240.21(B)(4)(2)*«.

Ⓓ The ampacity of the tap conductors shall not be less than one-third the rating of the overcurrent device protecting the feeder conductors »*240.21(B)(4)(3)*«.

Ⓔ Conditions of maintenance and supervision ensure that only qualified persons service the systems »*240.21(B)(4)(1)*«.

Ⓕ The conductor taps must be made no less than 30 ft (9 m) above the floor »*240.21(B)(4)(9)*«.

Ⓖ The tap conductors are continuous from end-to-end and contain no splices »*240.21(B)(4)(6)*«.

Ⓗ The tap conductors shall be protected from physical damage by being enclosed in an approved raceway or by other approved means »*240.21(B)(4)(5)*«.

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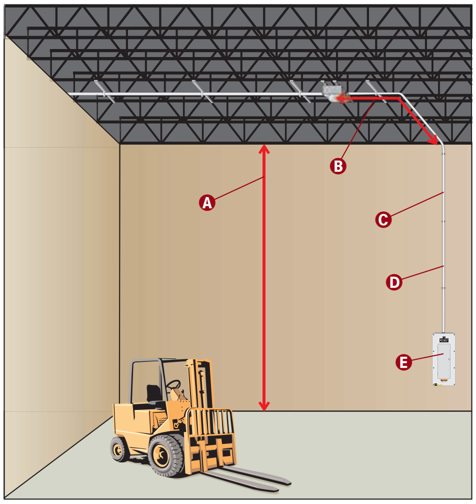
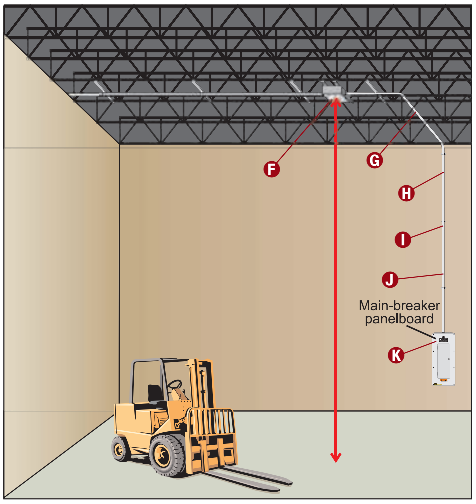
Tap Rule for High-Bay Manufacturing Building *(continued)*

I The size of the tap conductors shall be 6 AWG copper (or 4 AWG aluminum) or larger »*240.21(B)(4)(7)*«.

J The tap conductors shall not penetrate walls, floors, or ceilings »*240.21(B)(4)(8)*«.

K The tap conductors must terminate at a single circuit breaker or a single set of fuses that limit the load to the ampacity of the tap conductors. This single overcurrent device shall be permitted to supply any number of additional overcurrent devices on its load side »*240.21(B)(4)(4)*«.





Tap Conductors Supplying a Transformer

A A transformer's primary conductors shall have an ampacity at least one-third of the feeder conductors' overcurrent device rating »*240.21(B)(3)(1)*«.

B A 100-ampere rated conductor is the minimum size allowed if the overcurrent protection on the tap conductor's line side is 300 amperes (300 ÷ 3 = 100) »*240.21(B)(3)(1)*«.

C Primary and secondary conductors shall be protected from physical damage in an approved manner, such as enclosed in a raceway »*240.21(B)(3)(4)*«.

D Secondary conductors shall terminate in a single circuit breaker or set of fuses that will limit the load current to no more than the conductor ampacity permitted by 310.14 »*240.21(B)(3)(5)*«.

E Conductors supplied by the transformer's secondary shall have an ampacity that is not less than the value of the primary-to-secondary voltage ratio multiplied by one-third of the feeder conductors' overcurrent device rating »*240.21(B)(3)(2)*«.

Warning

The provisions of 240.4(B) shall not be permitted for tap conductors »*240.21(B)*«.

F The combined length of one primary plus one secondary conductor (excluding any portion of the primary conductor protected at its ampacity) shall not exceed 25 ft (7.5 m) »*240.21(B)(3)(3)*«.

G Conductors supplied from a set of fuses (or circuit breaker) and feeding a transformer are feeder conductors, not feeder tap conductors.

H Refer to this book's Unit 14 for transformer provisions (overcurrent protection, grounding, etc.).

I Transformer secondary conductor provisions are found in 240.21(C).

Caution

Transformers, other than Class 2 or Class 3 transformers, shall have a disconnecting means located either in sight of the transformer or in a remote location. Where located in a remote location, the disconnecting means shall be lockable in accordance with 110.25, and its location shall be field-marked on the transformer »*450.14*«.

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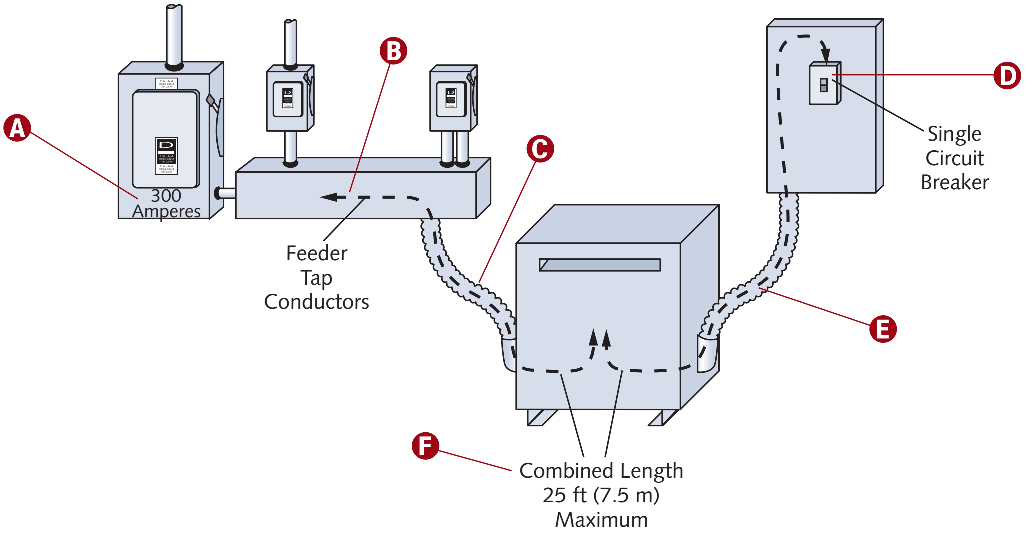
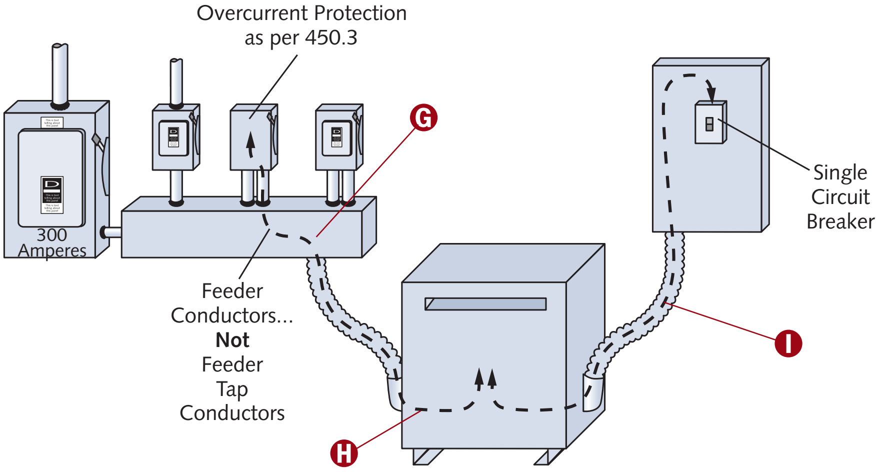

A
300 Amperes
B
Feeder Tap Conductors
C
D
Single Circuit Breaker
E
F
Combined Length 25 ft (7.5 m) Maximum

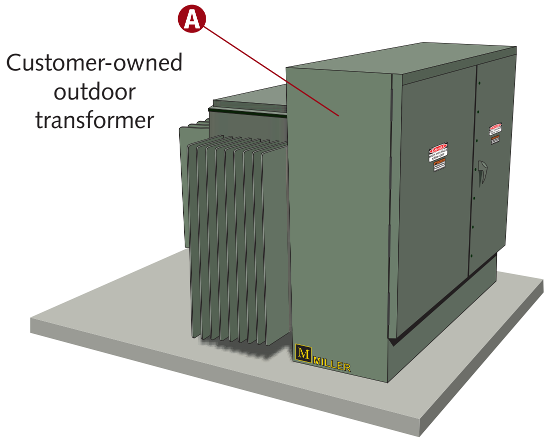

Overcurrent Protection as per 450.3
300 Amperes
G
Feeder Conductors... **Not** Feeder Tap Conductors
Single Circuit Breaker
H
I

Outside Transformer Secondary Conductors

Where installing outside secondary conductors, in accordance with the transformer secondary conductor rule in 240.21(C)(4), the following conditions shall be met:

1. **The conductors must be protected from physical damage in an approved manner.**
2. **The conductors must terminate at a single circuit breaker or a single set of fuses that limits the load to the ampacity of the conductors. This single overcurrent device can supply any number of additional overcurrent devices on its load side.**
3. **The overcurrent device for the conductors shall be an integral part of a disconnecting means or shall be located immediately adjacent thereto.**
4. **The disconnecting means for the conductors shall be installed at a readily accessible location complying with one of the following:**
   a. **Outside of a building or structure**
   b. **Inside, nearest the point of entrance of the transformer secondary conductors**
   c. **Where installed in accordance with 230.6, nearest the point of entrance of the transformer secondary conductors.**

A The fourth transformer secondary conductor rule in 240.21(C) can be utilized where the conductors are located outside of a building or structure. Although the transformer secondary conductors must be located outside when using this rule, the load terminations of the conductors can be located inside the building or structure. Like the outside feeder tap rule, length is not a factor.


A
Customer-owned outdoor transformer
MILLER

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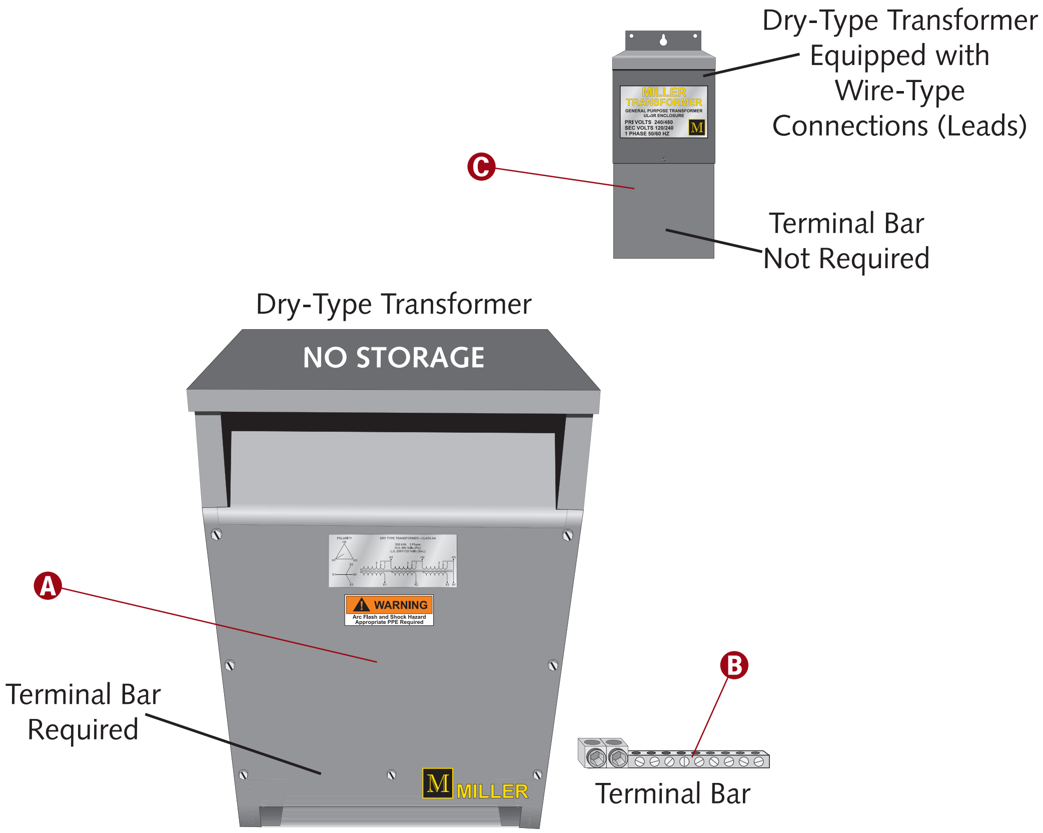
Dry-Type Transformer Terminal Bar

Ⓐ Where separate equipment grounding conductors and supply-side bonding jumpers are installed in a dry-type transformer, a terminal bar for all grounding and bonding conductor connections shall be secured inside the transformer enclosure »*450.10(A)*«.

Ⓑ The terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any vented portion of the enclosure »*450.10(A)*«.

Ⓒ Where a dry-type transformer is equipped with wire-type connections (leads), the grounding and bonding connections shall be permitted to be connected together using any of the methods in 250.8 and shall be bonded to the enclosure if of metal »*450.10(A) Exception*«.



Transformer Vaults

Wherever such an arrangement is practicable, transformer vaults shall be located so that ventilation to outside air does not rely on flues or ducts »*450.41*«.

Where required by 450.9, openings for ventilation shall also comply with 450.45(A) through (F) »*450.45*«. That section includes provisions pertaining to location, arrangement, size, covering, dampers, and ducts.

Each doorway from the building interior into the vault shall have a tight-fitting door with a minimum fire rating of three hours, unless the exception is met. The AHJ can require such a door for exterior wall openings where conditions warrant »*450.43(A)*«.

Doors shall be equipped with locks and kept locked, thereby limiting access to qualified persons only »*450.43(C)*«.

Personnel doors shall open 90 degrees in the direction of egress and be equipped with listed fire exit hardware »*450.43(C)*«.

Vaults containing more than 100-kVA transformer capacity shall have a drain or other means to carry off any oil or water accumulation, unless local conditions make this impracticable. The vault floor must pitch toward the drain, where provided »*450.46*«.

Nonelectrical pipe or duct systems shall neither enter nor pass through a transformer vault. Piping or other facilities

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providing vault fire protection, or transformer cooling, are allowed »*450.47*«.

Ⓐ Vault walls and roofs shall be constructed of materials having approved structural strength for the conditions and a minimum fire resistance of three hours. For this section's purpose, studs and wallboard construction shall not be permitted »*450.42*«.

Ⓑ Construction of one hour rating is permitted where transformers are protected with automatic sprinkler, water spray, carbon dioxide, or halon »*450.42 Exception* and *450.43(A) Exception*«.

Ⓒ Vault floors in contact with the earth shall be of concrete, no less than 4 in. (100 mm) thick. Where the vault is constructed above a vacant space (or other stories), the floor shall have approved structural strength for the load imposed on it and shall have a minimum fire resistance of three hours »*450.42*«.

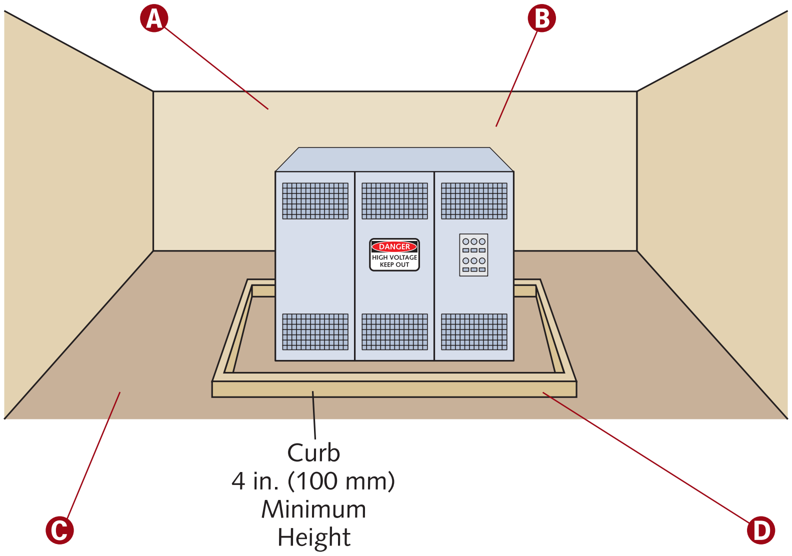
Ⓓ A door sill (or curb) of an approved height, at least 4 in. (100 mm), that will confine the oil from the largest transformer within the vault shall be provided »*450.43(B)*«.

Caution

Transformer vaults shall not be used for material storage »*450.48*«.

Note

Entrances to all buildings, rooms, or enclosures containing exposed live parts or exposed conductors operating at over 1000 volts, nominal, shall be kept locked, unless such entrances are constantly observed by qualified personnel. Permanent and conspicuous danger signs shall be provided. The danger sign shall meet the requirements in 110.21(B) and shall read as follows: *DANGER—HIGH VOLTAGE—KEEP OUT* »***110.34(C)***«.



Bonding Service Raceways

Ⓐ The supply-side bonding jumper shall not be smaller than specified in Table 250.102(C)(1) »*250.102(C)(1)*«. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum, the supply-side bonding jumper shall have an area not less than 12½% of the area of the largest ungrounded supply conductor or equivalent area for parallel supply conductors. If the circular mil area of ungrounded supply conductors that are connected in parallel is larger than 1100 kcmil copper or 1750 kcmil aluminum and if the ungrounded supply conductors and the bonding jumper are of different materials (copper, aluminum, or copper-clad aluminum), the minimum size of the supply-side bonding jumper shall be based on the assumed use of ungrounded supply conductors of the same material as the supply-side bonding jumper that has an ampacity equivalent to that of the installed ungrounded supply conductors »*Notes 1 and 2 under Table 250.102(C)(1)*«.

Ⓑ Here, one supply-side bonding jumper is used to bond *all* service raceways. This supply-side bonding jumper's size is based on the total combined ungrounded supply conductors' area.

Ⓒ Here, a supply-side bonding jumper bonds *each individual* service raceway. Each supply-side bonding jumper is sized according to each individual raceway's ungrounded supply conductors.

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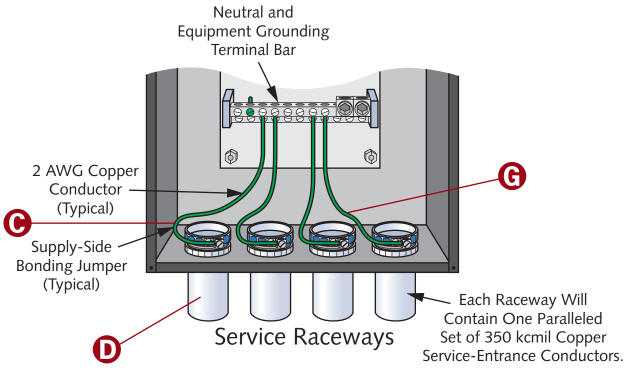
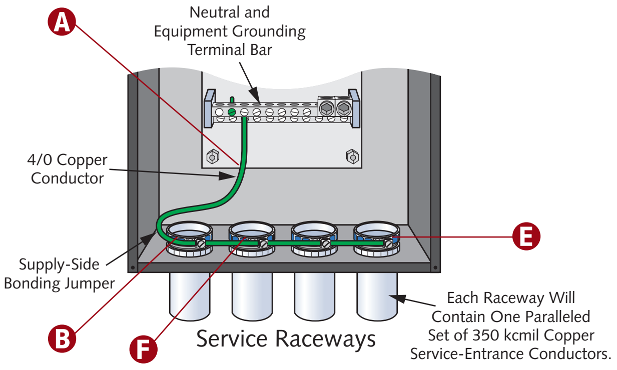
D Where the ungrounded supply conductors are paralleled in two or more raceways or cables, and an individual supply-side bonding jumper is used for bonding these raceways or cables, the size of the supply-side bonding jumper for each raceway or cable shall be selected from Table 250.102(C)(1) based on the size of the ungrounded supply conductors in each raceway or cable. A single supply-side bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with 250.102(C)(1) based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable »*250.102(C)(2)*«.

E The total ungrounded supply conductors' area is 1400 kcmil (350 × 4). The supply-side bonding jumper shall be at least 12½% of that area (1400 × 12.5% = 175 kcmil or 175,000 cmil). In accordance with Chapter 9, Table 8, a 3/0 AWG copper conductor (with a circular mil area of 167,800) is insufficient. Therefore, a 4/0 AWG copper conductor (with a circular mil area of 211,600) meets the minimum size requirement.

F The following normally non-current-carrying metal parts of equipment shall be bonded together: (1) all raceways, cable trays, cablebus framework, auxiliary gutters, or service cable armor or sheath that enclose, contain, or support service conductors, except as permitted in 250.80; and (2) all enclosures containing service conductors, including meter fittings, boxes, or the like, interposed in the service raceway or armor »*250.92(A)(1) and (2)*«.

G A supply-side bonding jumper is defined as a conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected »*Article 100*«.





Grounding Electrode Conductor Taps

The supply-side bonding jumper shall not be smaller than specified in Table 250.102(C)(1) »*250.102(C)(1)*«.

Where the ungrounded supply conductors are paralleled in two or more raceways or cables, and an individual supply-side bonding jumper is used for bonding these raceways or cables, the size of the supply-side bonding jumper for each raceway or cable shall be selected from Table 250.102(C)(1) based on the size of the ungrounded supply conductors in each raceway or cable. A single supply-side bonding jumper installed for bonding two or more raceways or cables shall be sized in accordance with 250.102(C)(1) based on the sum of the circular mil areas of the largest ungrounded conductors from each set connected in parallel in each raceway or cable »*250.102(C)(2)*«.

A If a building or structure is supplied by a service or feeder with two or more disconnecting means in separate enclosures supplying a building or structure, the grounding electrode connections shall be made in accordance with 250.64(D)(1), (D)(2), or (D)(3) »*250.64(D)*«. A common grounding electrode conductor and grounding electrode conductor taps shall be installed. The common grounding electrode conductor shall be sized in accordance with 250.66, based on the sum of the circular mil area of the largest ungrounded conductor(s) of each set of conductors that supplies the disconnecting means. If the service-entrance conductors connect directly to the overhead service conductors, service drop, underground service conductors, or service lateral, the common grounding electrode conductor shall be sized in accordance with Table 250.66, Note 1. A grounding electrode conductor tap shall extend to the inside of each service disconnecting means enclosure. The grounding electrode conductor taps shall be sized in accordance with 250.66 for the largest service-entrance or feeder conductor serving the individual enclosure. The tap conductors shall be connected to the common grounding electrode conductor by one of the following methods in such a manner that the common grounding electrode conductor remains without a splice or joint: (1) exothermic welding, (2) connectors listed as grounding and bonding equipment, (3) connections to an aluminum or copper busbar not less than ¼ in. thick × 2 in. wide (6 mm thick × 50 mm wide) and of sufficient length to accommodate the number of terminations necessary for the installation. The busbar shall be securely fastened and shall be installed in an accessible location. Connections shall be made by a listed connector or by the exothermic welding process. If aluminum busbars are used, the installation shall comply with 250.64(A) »*250.64(D)(1)*«.

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B The following normally non-current-carrying metal parts of equipment shall be bonded together: (1) all raceways, cable trays, cablebus framework, auxiliary gutters, or service cable armor or sheath that enclose, contain, or support service conductors, except as permitted in 250.80; and (2) all enclosures containing service conductors, including meter fittings, boxes, or the like, interposed in the service raceway or armor »*250.92(A)(1)* and *(2)*«.

C Bonding shall be provided where necessary to ensure electrical continuity and the capacity to conduct safely any fault current likely to be imposed »*250.90*«.

D The grounding electrode conductor shall be of one continuous length (without splice or joint), except as permitted in 250.30(A)(5) and (A)(6), 250.30(B)(1), and 250.68(C). If necessary, splices or connections shall be made as permitted in 250.64(C)(1) through (4) »*250.64(C)*«.

E Ferrous metal raceways, enclosures, and cable armor for grounding electrode conductors shall be electrically continuous from the point of attachment to cabinets or equipment to the grounding electrode and shall be securely fastened to the ground clamp or fitting. Ferrous metal raceways, enclosures, and cable armor shall be bonded at each end of the raceway or enclosure to the grounding electrode or grounding electrode conductor to create an electrically parallel path. Bonding shall be in compliance with 250.92(B) and ensured by one of the methods in 250.92(B)(2) through (B)(4) »*250.64(E)(1)* and *(E)(2)*«.

F A grounding electrode conductor shall be connected in a wireway or other accessible enclosure on the supply side of the disconnecting means to one or more of the following, as applicable:

(1) Grounded service conductor(s)
(2) Equipment grounding conductor installed with the feeder
(3) Supply-side bonding jumper.

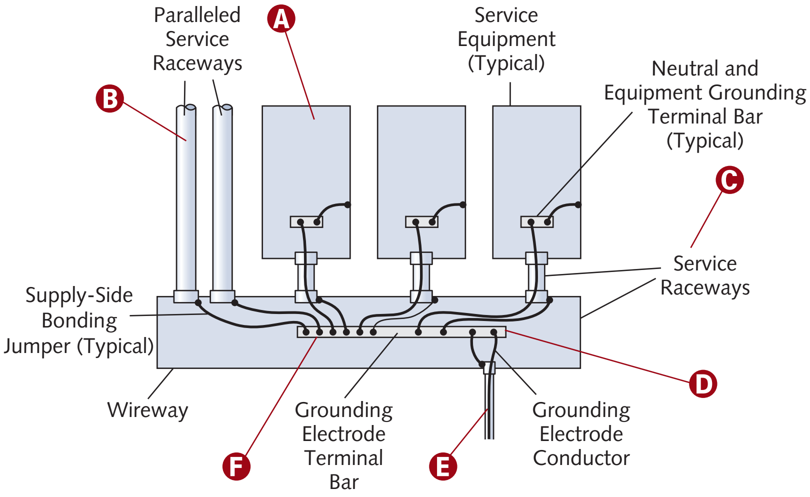
The connection shall be made with exothermic welding or a connector listed as grounding and bonding equipment. The grounding electrode conductor shall be sized in accordance with 250.66 based on the service-entrance or feeder conductor(s) at the common location where the connection is made »*250.64(D)(3)*«.

Note

A grounding electrode conductor shall be connected between the grounding electrode system and one or more of the following, as applicable:

(1) Grounded conductor in each service equipment disconnecting means enclosure
(2) Equipment grounding conductor installed with the feeder(s) or branch circuit(s)
(3) Supply-side bonding jumper.

Each grounding electrode conductor shall be sized in accordance with 250.66 based on the service-entrance or feeder conductor(s) supplying the individual disconnecting means »**250.64(D)(2)**«.


Paralleled Service Raceways
A
Service Equipment (Typical)
Neutral and Equipment Grounding Terminal Bar (Typical)
B
C
Service Raceways
Supply-Side Bonding Jumper (Typical)
D
Wireway
Grounding Electrode Terminal Bar
Grounding Electrode Conductor
F
E

Equipment Grounding Conductors

A single equipment grounding conductor shall be permitted to be installed for multiple circuits that are installed in the same raceway, cable, trench, or cable tray. It shall be sized from Table 250.122 for the largest overcurrent device protecting circuit conductors in the raceway, cable, trench, or cable tray. Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c) »*250.122(C)*«.

While copper, aluminum, or copper-clad aluminum equipment grounding conductors of the wire type shall not be smaller than shown in Table 250.122, in no case, are they required to be larger than the circuit conductors supplying the equipment »*250.122(A)*«.

Where a raceway, cable tray, or cable armor (or sheath) serves as the equipment grounding conductor, as provided in 250.118 and 250.134(A)(1), it shall comply with 250.4(A)(5) or 250.4(B)(4). Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with Table 250.122 »*250.122(A)*«.

Ⓐ Since the overcurrent protection has a rating of 1200 amperes, the minimum size equipment grounding conductor is 3/0 AWG copper (or 250-kcmil aluminum) »*Table 250.122*«.

Ⓑ Because wire-type equipment grounding conductors are used, each equipment grounding conductor shall be sized in compliance with 250.122 »*250.122(F)(1)(b)*«.

Ⓒ Equipment grounding conductor provisions are not limited to feeders. For example, an alternative drawing could have shown one piece of equipment supplied by a paralleled set of branch-circuit conductors. Equipment grounding conductor provisions also apply to branch circuits.

Ⓓ Unlike service-equipment bonding jumpers, which can be sized according to each paralleled raceway's service-entrance conductor size, a **full-size** equipment grounding conductor (where used) must be installed in **each** raceway.

Ⓔ If conductors are installed in parallel in multiple raceways and are connected in parallel, a wire-type equipment grounding conductor, if used, shall be installed in each raceway and shall be connected in parallel. The equipment grounding conductor installed in each raceway shall be sized in accordance with 250.122 based on the rating of the overcurrent protective device for the feeder or branch circuit »*250.122(F)(1)(b)*«. Wire-type equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c) »*250.122(F)(1)(c)*«. Metal raceways or auxiliary gutters in accordance with 250.118 or cable trays complying with 392.60(B) shall be permitted as the equipment grounding conductor »*250.122(F)(1)(d)*«.

Ⓕ If a single raceway or cable tray was used to supply the equipment, only one 3/0 AWG copper (or 250-kcmil aluminum) equipment grounding conductor would have been required. See 250.122(F)(1)(a) for conductor installations in a single raceway or cable tray.

Warning

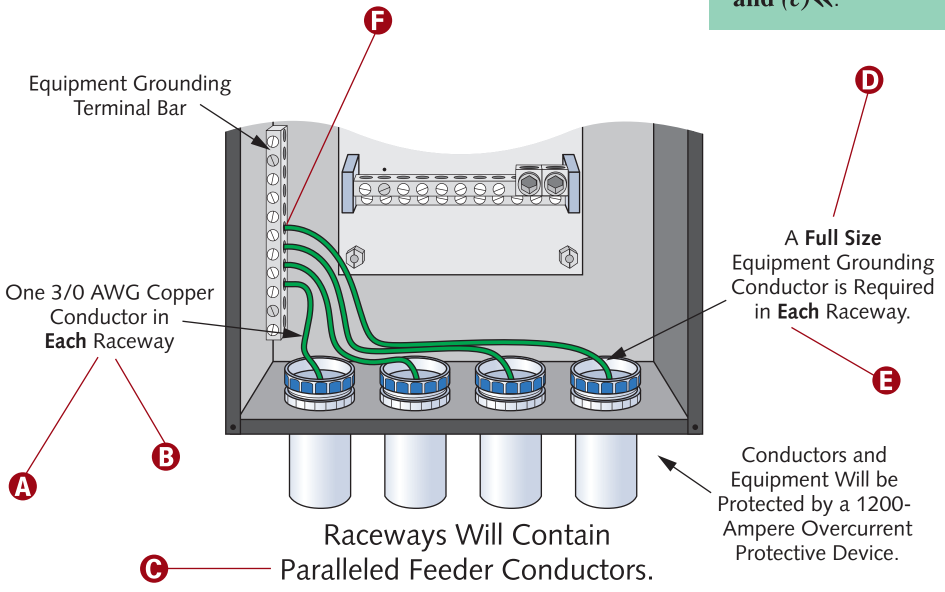
A grounding electrode conductor or structural metal frame of a building or structure shall not be used as an equipment grounding conductor »*250.118(B)(1)* and *(2)*«. A wire-type equipment grounding conductor installed in compliance with 250.6(A) and the applicable requirements for both the equipment grounding conductor and the grounding electrode conductor in Parts II, III, and VI of this article shall be permitted to serve as both an equipment grounding conductor and a grounding electrode conductor »*250.118(B)(1) Exception*«.

Note

If ungrounded conductors are increased in size for any reason other than as required in 310.15(B) or (C), wire-type equipment grounding conductors, if installed, shall be increased in size proportionately to the increase in circular mil area of the ungrounded conductors »***250.122(B)***«.

Note

If circuit conductors of multiconductor cables are connected in parallel, the equipment grounding conductor(s) in each cable shall be connected in parallel. If multiconductor cables are paralleled in the same raceway, auxiliary gutter, or cable tray, a single equipment grounding conductor that is sized in accordance with 250.122 shall be permitted in combination with the equipment grounding conductors provided within the multiconductor cables and shall all be connected together. Except as provided in 250.122(F)(2)(c) for raceway or cable tray installations, the equipment grounding conductor in each multiconductor cable shall be sized in accordance with 250.122 based on the overcurrent protective device for the feeder or branch circuit »***250.122(F)(2)(a), (b), and (c)***«.


Ⓕ
Equipment Grounding Terminal Bar
Ⓓ
A **Full Size** Equipment Grounding Conductor is Required in **Each** Raceway.
One 3/0 AWG Copper Conductor in **Each** Raceway
Ⓔ
Ⓑ
Ⓐ
Conductors and Equipment Will be Protected by a 1200-Ampere Overcurrent Protective Device.
Ⓒ
Raceways Will Contain Paralleled Feeder Conductors.

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Cable Trays

Cable tray installations are not limited to industrial establishments. Wiring methods in Table 392.10(A) can be installed in cable tray systems under the conditions described in their respective articles and sections »*392.10* and *10(A)*«.

Only in industrial establishments, where maintenance and supervision conditions restrict cable tray system service to qualified personnel, can any of the cables in 392.10(B)(1) and (2) be installed in ladder, ventilated troughs, solid-bottom, or ventilated-channel cable trays »*392.10(B)*«.

Cable tray systems shall be corrosion resistant. If made of ferrous material, the system shall be protected from corrosion per 300.6 »*392.100(C)*«.

Steel or aluminum cable tray systems can be used as equipment grounding conductors provided all 392.60(B)(1) through (4) conditions are met.

While provisions pertaining to the number of multiconductor cables (rated 2000 volts or less) can be found in 392.22(A), 392.22(B) contains single conductor cable provisions.

A Cable trays can extend transversely through partitions and walls, or vertically through platforms and floors, in either wet or dry locations where the completed installation meets 300.21 requirements »*392.18(D)*«.

B Sufficient space shall be provided and maintained around cable trays to permit adequate access for cable installation and maintenance »*392.18(F)*«.

C Cable trays shall be of adequate strength and rigidity to provide support for all contained wiring »*392.100(A)*«.

D A cable tray system is a unit (or assembly of units or sections) and associated fittings that together form a structural system used to securely fasten/support cables and raceways »*Article 100*«.

E Cable trays shall be exposed and accessible except as permitted by 392.18(D) »*392.18(E)*«.

F Cable trays shall include fittings or other suitable means to facilitate changes in direction and elevation »*392.100(E)*«.

G Cable trays shall have side rails or similar structural members »*392.100(D)*«.

H Metal cable trays can serve as equipment grounding conductors where (1) continuous maintenance and supervision ensures that qualified persons service the installed cable tray system and (2) the cable tray complies with 392.60 provisions »*392.60(A)*«.

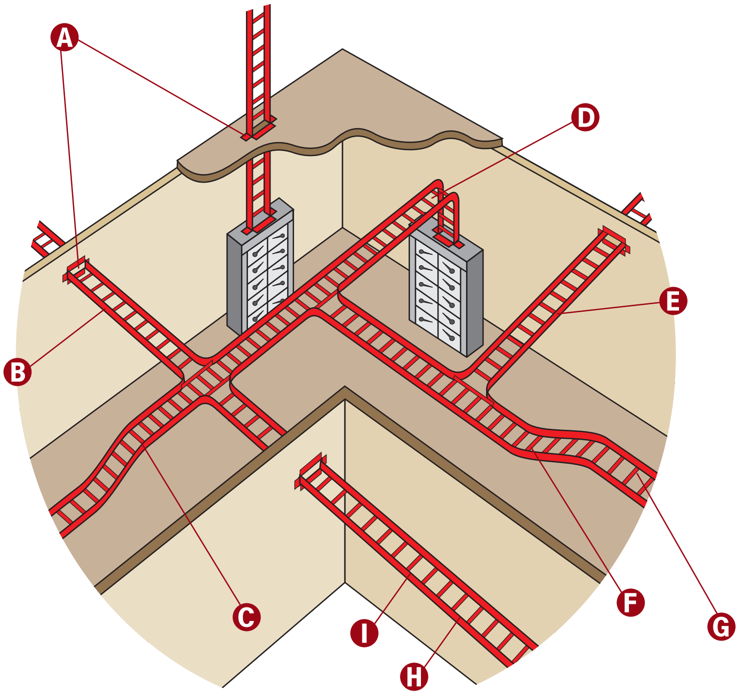
I Each cable tray run shall be completed before cables are installed »*392.18(B)*«.

Caution

Cable trays in hazardous (classified) locations shall contain only the cable types and raceways permitted by other articles in the *NEC*® »*392.10(C)*«.

Note

Cable tray systems shall not be used in hoistways or where subject to severe physical damage »*392.12*«.



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Motors

General Motor Provisions

Article 430 covers motors and all of the following as they relate specifically to motors: branch-circuit and feeder conductors and their protection, overload protection, control circuits, controllers, and motor-control centers »*430.1*«.

Wires passing through an opening in an enclosure, conduit box, or barrier require a bushing to protect the conductors from any sharp opening edges »*430.13*«.

A Article 430, Part V specifies protective devices designed to protect feeder conductors supplying motors against overcurrents due to short circuits or ground-faults »*430.61*«.

B Sections 430.24 through 430.26 contain provisions for conductors supplying multiple motors, or a motor(s) and other load(s). These provisions are applicable to more than feeder conductors.

C Article 430, Part IV specifies devices that are used to protect motor branch-circuit conductors, motor-control apparatus, and motors against overcurrent due to short circuits or ground faults »*430.51*«.

D Article 430, Part II specifies ampacities of conductors capable of carrying the motor current without overheating, under specified conditions »*430.21*«.

E Article 430, Part III specifies overload devices intended to protect motors, motor-control apparatus, and motor branch-circuit conductors against excessive heating due to motor overloads and failure to start »*430.31*«.

Overload is defined as operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload »*Article 100*«.

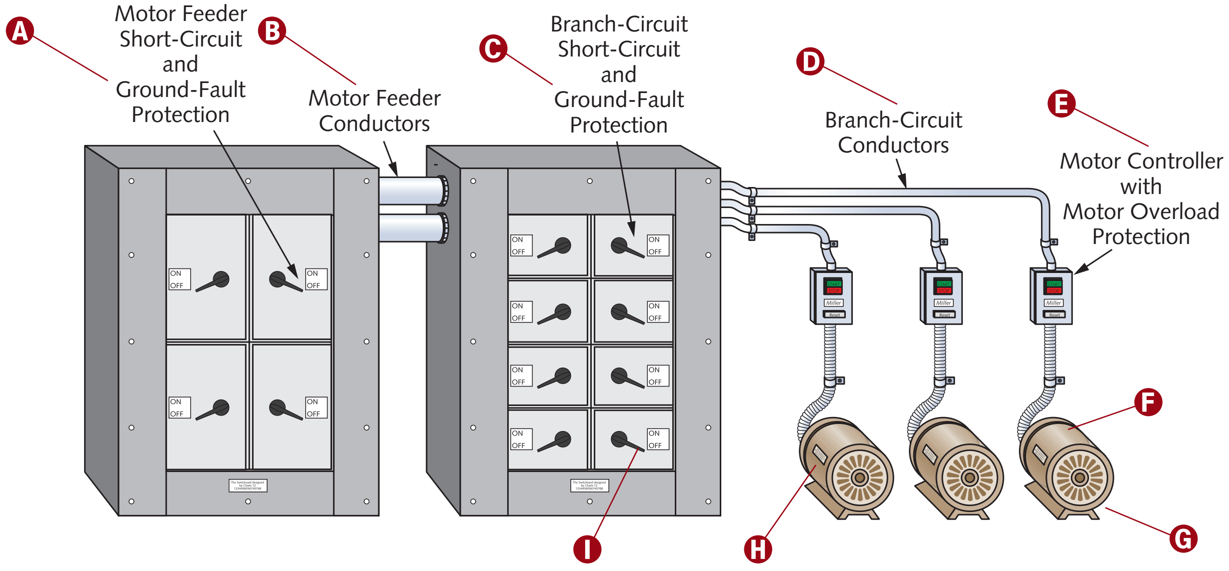
F General motor provisions are found in 430.1 through 430.18 (Part I).

G Part XIII of Article 430 addresses the grounding of exposed non-current-carrying metal parts of motor and motor controller frames that are likely to become energized to limit voltage to ground should accidental contact between energized parts and frames occur. Insulation, isolation, or guarding are suitable alternatives to grounding of motors under certain conditions »*430.241*«.

H For general motor applications, base current ratings on 430.6(A)(1) and (2): (1) Other than for motors built for low speeds (less than 1200 rpm) or high torques, and for multispeed motors, use the values given in Tables 430.247 through 430.250 (including notes) to determine conductor ampacity or current ratings of switches, branch-circuit short-circuit, and ground-fault protection. Do not use the actual current ratings marked on the motor nameplate unless an exception applies and (2) Separate motor overload protection is based on the motor nameplate current rating »*430.6(A)*«.

I Motor disconnecting means provisions are found in 430.101 through 430.113 (Part IX).

Note
Motor tables are located in Part XIV of Article 430.


A
Motor Feeder Short-Circuit and Ground-Fault Protection
B
Motor Feeder Conductors
C
Branch-Circuit Short-Circuit and Ground-Fault Protection
D
Branch-Circuit Conductors
E
Motor Controller with Motor Overload Protection
F
G
H
I
ON
OFF

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Motor and Branch-Circuit Overload Protection

Each continuous-duty motor rated 1 hp or less, *not* permanently installed, nonautomatically started, and within sight of the controller can be protected against overloads by the branch-circuit short-circuit and ground-fault device. Comply with branch-circuit overcurrent protection size specifications found in Article 430, Part IV »*430.32(D)(2)*«.

Any automatically started motor, 1 hp or less, must be protected against overload by one of the methods found in 430.32(B)(1) through (4).

A motor controller can serve as an overload device if the number of overload units complies with Table 430.37, and if these units are operative in both the starting and running position (dc motor), or in the running position (ac motor) »*430.39*«.

Overload relays and other devices for motor overload protection incapable of opening short circuits or ground faults shall be protected by fuses (or circuit breakers) rated or set according to 430.52, or by a motor short-circuit protector per 430.52 »*430.40*«.

Overload protection for motors on general-purpose branch circuits (permitted by Article 210) is required and must meet 430.42(A), (B), (C), or (D) specifications.

A As an approved method of protecting a motor against overload, 430.32(A)(1) lists a separate overload device responsive to motor current. This device must be selected to trip or shall be rated at no more than the percentage of the motor nameplate full-load current rating shown here:

Motors with a marked service factor not less than 1.15	125%
Motors with a marked temperature rise not over 40 degrees C	125%
All other motors	115%

B Motor controllers must be marked according to 430.8 provisions.

Caution

A motor overload device, which restarts a motor automatically after overload tripping, shall not be installed if automatic restarting can result in injury to persons »*430.43*«.

Note

Any motor application shall be considered continuous duty unless the driven apparatus, by nature, means the motor shall not, under any conditions, operate continuously with the load »*430.33*«.

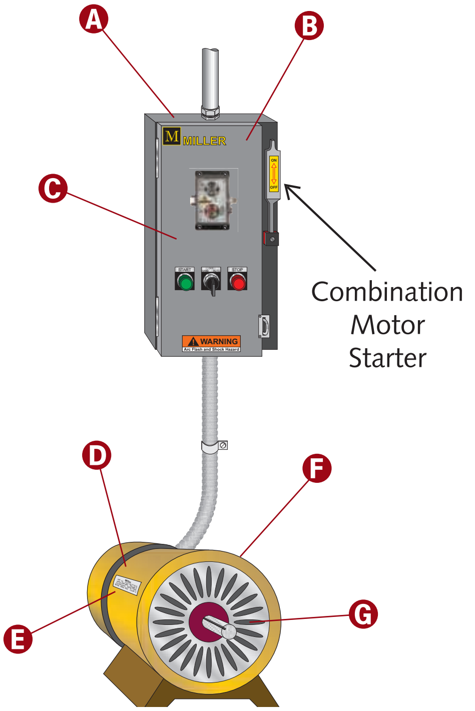
C Article 430, Part III specifies overload devices intended to protect motors, motor-control apparatus, and motor branch-circuit conductors against excessive heating due to motor overloads and failure to start »*430.31*«.

D Separate motor overload protection shall be based on the actual motor nameplate current rating, not on the ratings listed in Tables 430.247 through 430.250 »*430.6(A)(2)*«.

E Motors (in usual applications) must be marked with the information listed in 430.7(A)(1) through (16).

F Each motor used in a continuous-duty application rated more than 1 hp must be protected against overload by a means listed in 430.32(A)(1) through (4).

G **Overload** is defined as operation of equipment in excess of normal, full-load rating, or of a conductor in excess of rated ampacity that, when it persists for a sufficient length of time, would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload »*Article 100*«.



Warning

Section 430, Part III provisions *do not* require overload protection where a power loss would cause a hazard, such as with fire pumps »*430.31(A)*«. For fire pump supply conductor protection, see 695.6.

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Motors on General-Purpose Branch Circuits

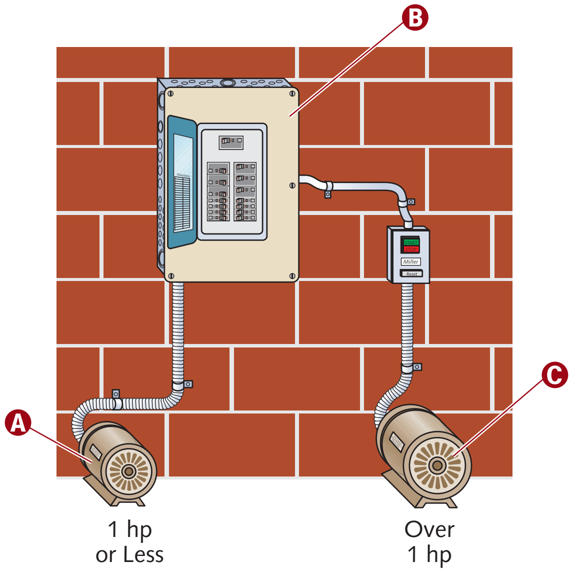
Where a motor without individual overload protection (as provided in 430.42[A]) is connected to a branch circuit by means of an attachment plug and a receptacle or cord connector, the attachment plug and receptacle or cord connector rating shall not exceed 15 amperes at either 125 or 250 volts. Where individual overload protection is required per 430.42(B) for a motor or motor-operated appliance attached to a branch circuit through an attachment plug and a receptacle or a cord connector, the overload device shall be an integral part of the motor/appliance. The rating of the attachment plug and receptacle or cord connector determines the rating of the circuit to which the motor may be connected, as provided in 210.21(B) »*430.42(C)*«.

The branch-circuit short-circuit and ground-fault protective device of a circuit to which a motor (or motor-operated appliance) is connected shall have a time delay sufficient to start the motor and allow it to accelerate »*430.42(D)*«.

A One or more motors without individual overload protection can be connected to a general-purpose branch circuit only if the installation complies with the limiting conditions of 430.32(B) and (D) and 430.53(A)(1) and (A)(2) »*430.42(A)*«.

B Motors used on general-purpose branch circuits require overload protection per 430.42(A), (B), (C), or (D) specifications »*430.42*«.

C Motors of larger ratings than specified in 430.53(A) can be connected to general-purpose branch circuits only if each motor has overload protection as specified in 430.32. Both the motor controller and the motor overload device shall be approved for group installation, and the short-circuit and ground-fault protective device shall be selected according to 430.53 »*430.42(B)*«.



Motor Branch-Circuit Conductors

Conductors for motors used in short-time, intermittent, periodic, or varying duty applications shall have an ampacity of no less than the percentage of the motor nameplate current rating shown in Table 430.22(E), unless the AHJ grants special permission for conductors of lower ampacity »*430.22(E)*«.

Where motor circuits contain capacitors, conductors shall comply with 460.8 and 460.9 »*430.27*«.

For a multispeed motor, the selection of branch-circuit conductors on the line side of the controller shall be based on the highest of the full-load current ratings shown on the motor nameplate. The ampacity of the branch-circuit conductors between the controller and the motor shall not be less than 125% of the current rating of the winding(s) that the conductors energize »*430.22(B)*«.

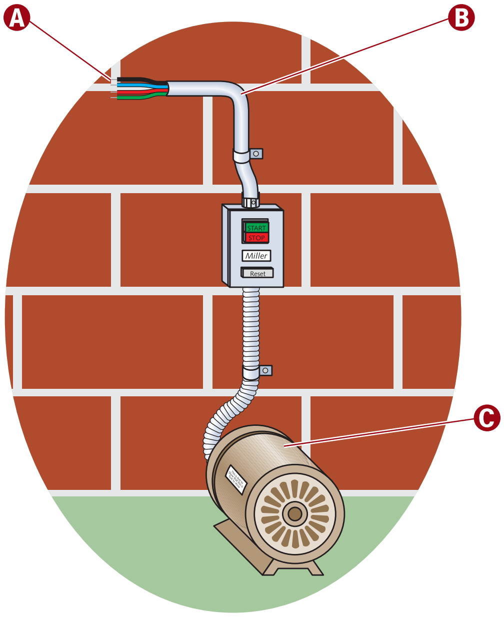
A Branch-circuit conductors supplying a single motor used in a continuous-duty application shall have an ampacity of at least 125% of the motor's full load current rating as determined by 430.6(A)(1), or not less than specified in 430.22(A) through (G) »*430.22*«.

Note

Conductors supplying several motors, or a motor(s) and other load(s), must comply with 430.24.

B Annex D contains sample motor calculations (see example D8).

C Placement of motors shall allow adequate ventilation and facilitate maintenance, such as bearing lubrication and brush replacement »*430.14(A)*«.



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Motor Branch-Circuit Short-Circuit and Ground-Fault Protection

Part IV specifies devices intended to protect the motor branch-circuit conductors, motor-control apparatus, and the motors against overcurrent due to short circuits or ground faults »*430.51*«.

Where the rating specified in Table 430.52(C)(1), or the rating modified by 430.52(C)(1)(a), is not sufficient for the motor's starting current, apply 430.52(C)(1)(b) (1) through (4) provisions »*430.52(C)(1)(b)*«.

Semiconductor fuses intended for the protection of electronic devices shall be permitted in lieu of devices listed in Table 430.52(C)(1) for power electronic devices, associated electromechanical devices (such as bypass contactors and isolation contactors), and conductors in a solid-state motor controller system, provided replacement fuse markings are adjacent to the fuses »*430.52(C)(5)*«.

A listed self-protected combination motor controller may be substituted for the devices specified in Table 430.52(C)(1) »*430.52(C)(6)*«.

Torque motor branch circuits shall be protected at the motor nameplate current rating according to 240.4(B) »*430.52(D)*«.

The branch-circuit short-circuit and ground-fault protective device rating for multimotor and combination-load equipment shall not exceed the equipment's marked rating in accordance with 430.7(D) »*430.54*«.

Where fuses are used for motor branch-circuit short-circuit and ground-fault protection, the fuseholders shall be of adequate size to accommodate the fuses specified by Table 430.52(C)(1) »*430.57*«. (An exception is provided for fuses having a time delay appropriate for the motor's starting characteristics.)

A circuit breaker for motor branch-circuit short-circuit and ground-fault protection shall have a current rating as determined by 430.52 and 430.110 »*430.58*«.

Ⓐ Where the values for branch-circuit short-circuit and ground-fault protective devices (determined by Table 430.52(C)(1)) do not correspond to the standard ampere ratings and settings provided in 240.6, the next higher standard rating or setting shall be permitted »*430.52(C)(1)(a)*«.

Ⓑ Use a protective device whose rating (or setting) does not exceed the value calculated according to Table 430.52(C)(1) »*430.52(C)(1)*«.

Ⓒ The motor branch-circuit short-circuit and ground-fault protective device shall comply with 430.52(B) and either (C) or (D), as applicable »*430.52(A)*«.

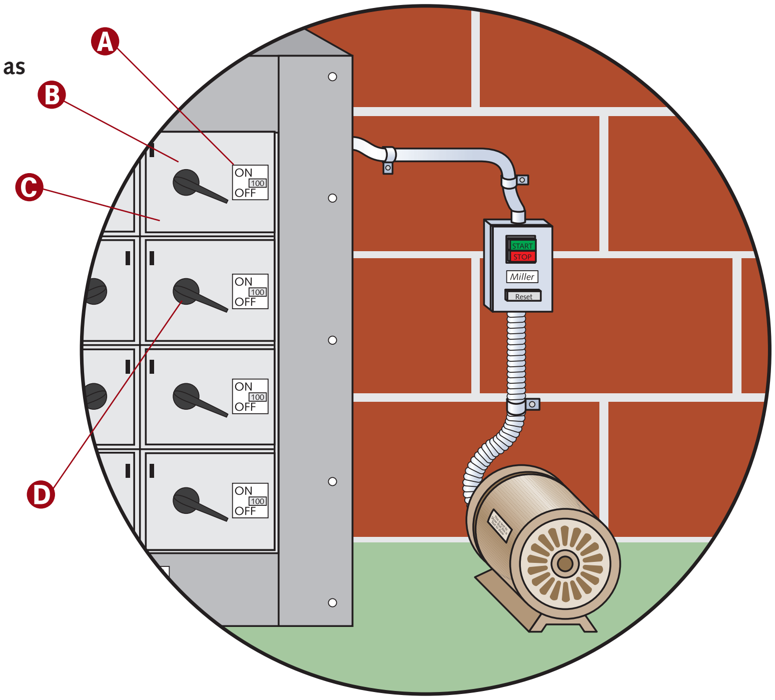
Ⓓ Branch-circuit protective devices shall comply with 240.15 provisions »*430.56*«.

Note

The motor branch-circuit short-circuit and ground-fault protective device shall be able to carry the motor's starting current »***430.52(B)***«.

Caution

If the maximum branch-circuit short-circuit and ground-fault protective device ratings are shown in the manufacturer's overload relay table (for use with a motor controller), or are otherwise marked on the equipment, they shall not be exceeded even if 430.52(C)(1) allows higher values »*430.52(C)(2)*«.



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Motor Disconnecting Means

The disconnecting means shall open all ungrounded supply conductors and shall be designed so that no pole operates independently. The disconnecting means can occupy the same enclosure as the motor controller. The disconnecting means shall be designed so that it cannot be closed automatically *»430.103«*.

The disconnecting means shall plainly indicate whether it is in the open (off) or closed (on) position *»430.104«*.

Motor-control circuits' arrangement shall accommodate disconnection from all supply sources when the disconnecting means is in the open position *»430.75(A)«*.

Where two or more motors are used together or where one or more motors are used in combination with other loads, such as resistance heaters, and where the combined load can be simultaneous on a single disconnecting means, the current and horsepower ratings of the combined load shall be determined in accordance with provisions in 430.110(C)(1) though (3) *»430.110(C)«*.

A switch (or circuit breaker) can serve as both controller and disconnecting means if it complies with 430.111(A) and is one of a type listed in 430.111(B) *»430.111«*.

Every motor-circuit disconnecting means between the branch circuit's or feeder's point of attachment and the motor's connection point shall comply with the requirements of 430.109 and 430.110 *»430.108«*.

The disconnecting means shall be a type specified in 430.109(A), unless otherwise permitted in (B) through (G), under the conditions given *»430.109«*.

Ⓐ Motor circuits rated 1000 volts, nominal, or less, shall have a disconnecting means with a current rating of at least 115% of the motor's full-load current rating *»430.110(A)«*.

Ⓑ A motor controller is defined as any switch (or device) normally used to start and stop a motor by making and breaking motor circuit current *»Article 100«*.

Ⓒ An individual disconnecting means shall be provided for each motor controller. The disconnecting means shall be located in sight from the motor controller location, unless an exception is met *»430.102(A)«*. The motor controller disconnecting means required in accordance with 430.102(A) shall be permitted to serve as the disconnecting means for the motor if it is in sight from the motor location and the driven machinery location *»430.102(B)(2)«*.

Ⓓ A disconnecting means shall be located in sight from the motor and driven machinery location *»430.102(B)(1)«*.

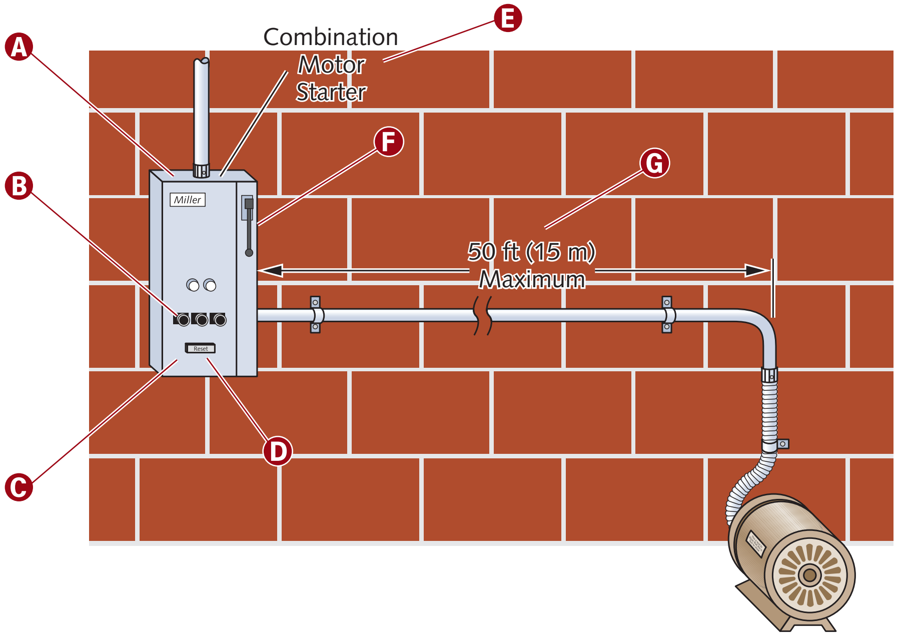
Ⓔ Motor branch-circuit and ground-fault protection and motor overload protection can be combined into a single device, where the device's rating (or setting) provides the overload protection required by 430.32 *»430.55«*.

Ⓕ Part IX of Article 430 requires a disconnecting means capable of breaking the connection between the motors and motor controllers and the circuit *»430.101«*.

Ⓖ The phrase "in sight from" indicates that specified items of equipment are visible and are no more than 50 ft (15 m) apart *»Article 100«*.

Note

At least one of the disconnecting means shall be **readily** accessible ***»430.107«***.



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Motor-Control Centers

At motor-control center terminals, minimum wire bending space as well as minimum gutter space shall comply with 312.6 »*430.97(C)*«.

Any motor-control center used as service equipment shall be provided with a single main disconnecting means to disconnect all ungrounded service conductors »*430.95*«.

Spacing between motor-control center bus terminals and other bare metal parts shall meet Table 430.97(D) specifications »*430.97(D)*«.

Barriers are required in all service-entrance motor-control centers to isolate service busbars and terminals from the remainder of the motor-control center »*430.97(E)*«.

Motor-control centers shall be marked according to 110.21, and the markings shall remain plainly visible after installation. Common power bus current rating and motor-control center short-circuit current rating shall be included in the marking »*430.98(A)*«.

A Article 430, Part VIII covers motor-control centers installed for the control of motors, lighting, and power circuits »*430.92*«.

B Multisection motor-control centers shall be connected together with an equipment grounding conductor, or an equivalent equipment grounding bus, sized according to Table 250.122. Equipment grounding conductors shall be connected to this equipment grounding bus or to a grounding termination point within a single-section motor-control center »*430.96*«.

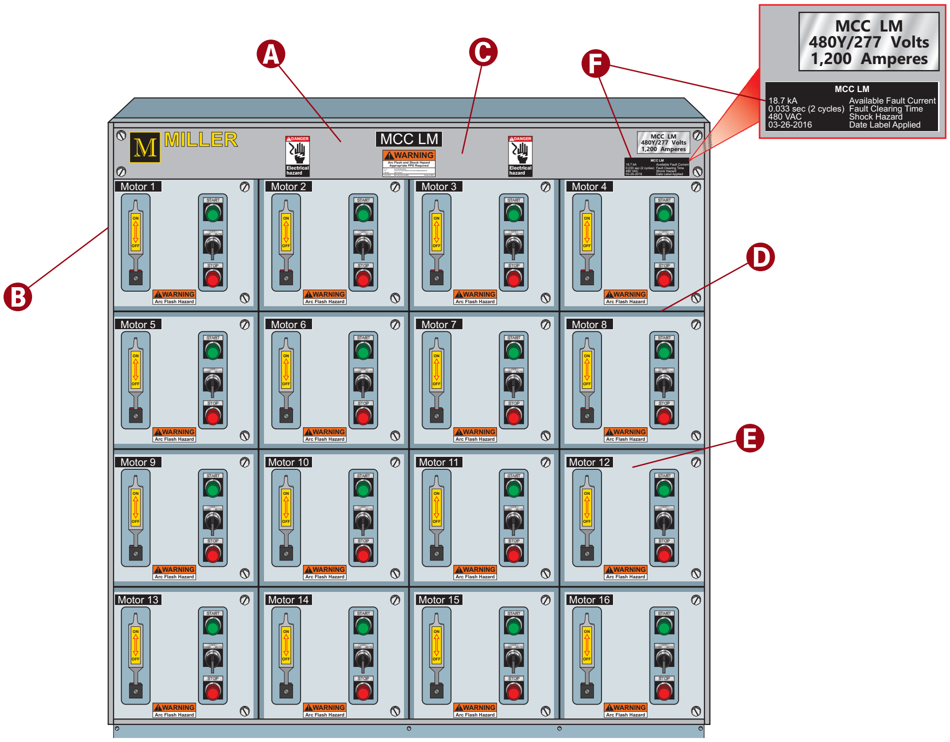
C Motor-control centers shall have overcurrent protection in accordance with Parts I, II, and VIII of Article 240. The ampere rating or setting of the overcurrent protective device shall not exceed the rating of the common power bus. This protection shall be provided by (1) an overcurrent protective device located ahead of the motor-control center or (2) a main overcurrent protective device in the motor-control center »*430.94*«.

D Horizontal travel through vertical sections is acceptable where a barrier isolates the conductors from the busbars »*430.97(A) Exception*«.

E Secure busbars firmly in place and provide adequate protection from physical damage. Other than those required for interconnections and control wiring, only the conductors that terminate can be located within that vertical section »*430.97(A)*«.

F The available fault current at the motor control center and the date the available fault current calculation was performed shall be documented and made available to those authorized to inspect, install, or maintain the installation »*430.99*«.

> **Note**
>
> Motor-control units within a motor-control center shall comply with 430.8 »***430.98(B)***«.
>
> Motor-control circuit installations must comply with Article 430, Part VI (430.71 through 75).


A
C
F
B
D
E
MILLER
DANGER
Electrical hazard
MCC LM
WARNING
Arc Flash and Shock Hazard
Appropriate PPE Required
MCC LM
480Y/277 Volts
1,200 Amperes
MCC LM
18.7 kA Available Fault Current
0.033 sec (2 cycles) Fault Clearing Time
480 VAC Shock Hazard
03-26-2016 Date Label Applied
Motor 1
Motor 2
Motor 3
Motor 4
Motor 5
Motor 6
Motor 7
Motor 8
Motor 9
Motor 10
Motor 11
Motor 12
Motor 13
Motor 14
Motor 15
Motor 16
ON
OFF
START
HAND OFF AUTO
STOP
WARNING
Arc Flash Hazard

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Feeder Conductors

Where one or more of the motors of the group are used for short-time, intermittent, periodic, or varying duty, the ampere rating of such motors (used in the calculation) is determined by 430.22(E). For the highest rated motor, the greater of (1) the ampere rating from 430.22(E) or (2) the largest continuous-duty motor full-load current multiplied by 1.25 is used »*430.24 Exception No. 1*«.

The ampacity of conductors supplying motor-operated fixed electric space-heating equipment shall conform to 424.4(B) specifications »*430.24 Exception No. 2*«.

Where interlocked circuitry prevents simultaneous operation of selected motors (or other loads), the conductor ampacity can be based on the highest possible total of motor and other load currents to be operated simultaneously »*430.24 Exception No. 3*«.

Feeder tap conductors must comply with 430.28 provisions.

Note

To ensure compliance with 430.24, 430.53(B), and 430.53(C), the highest rated, or smallest rated, motor shall be based on the rated full-load current selected from Tables 430.247, 430.248, 430.249, and 430.250 ***»430.17«***.

Ⓐ Conductors supplying several motors or a motor(s) and other load(s) shall have an ampacity not less than the sum of each of the following:

(1) 125% of the full-load current rating of the highest rated motor, as determined by 430.6(A),

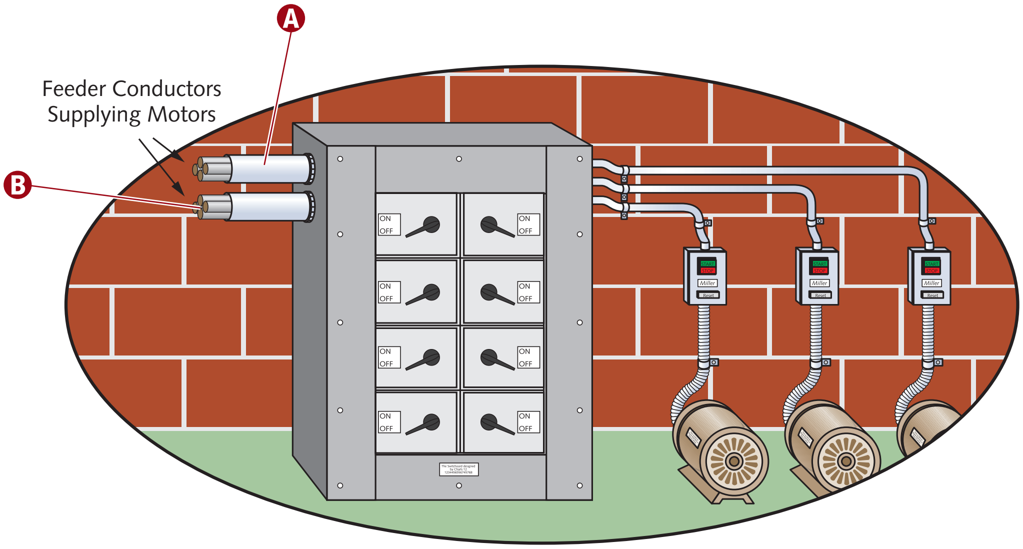
(2) Sum of the full-load current ratings of all the other motors in the group, as determined by 430.6(A),

(3) 100% of the noncontinuous nonmotor load, and

(4) 125% of the continuous nonmotor load »*430.24*«.

In other words, multiply the largest motor full-load current (FLC) rating by 125% and add the FLC ratings of all other motors (or loads) in the group. Note, any nonmotor loads that are continuous shall be added to the calculation at 125%.

Ⓑ Where reduced heating of the conductors results from duty-cycle operation, intermittent operation, or from all motors not operating at one time, the AHJ may allow a lower feeder-conductor ampacity than that specified in 430.24, provided the conductors' ampacity is sufficient for the maximum load determined according to the size and number of motors supplied and the character of their respective loads and duties »*430.26*«.



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Motor Feeder Short-Circuit and Ground-Fault Protection

Where instantaneous trip circuit breaker(s) or motor short-circuit protector(s) are used for motor branch-circuit short-circuit and ground-fault protection, per 430.52(C), the maximum rating of each instantaneous-trip circuit breaker or motor short-circuit protector shall be assumed to have a rating not exceeding the maximum percentage of motor FLC permitted by Table 430.52(C)(1) for the type of feeder protective device used »*430.62(A) Exception No. 1*«.

Where the feeder overcurrent protective device also provides overcurrent protection for a motor control center, the provisions of 430.94 shall apply »*430.62 Exception No. 2*«.

Where feeder conductor ampacity is greater than 430.24 requires, the rating (or setting) of the feeder overcurrent protective device can be based on the feeder conductor's ampacity »*430.62(B)*«.

Where the same rating (or setting) of the branch-circuit short-circuit and ground-fault protective device is used on multiple branch circuits supplied by the feeder, one of the protective devices is considered the largest for the calculation in 430.62(A) »*430.62(A)*«.

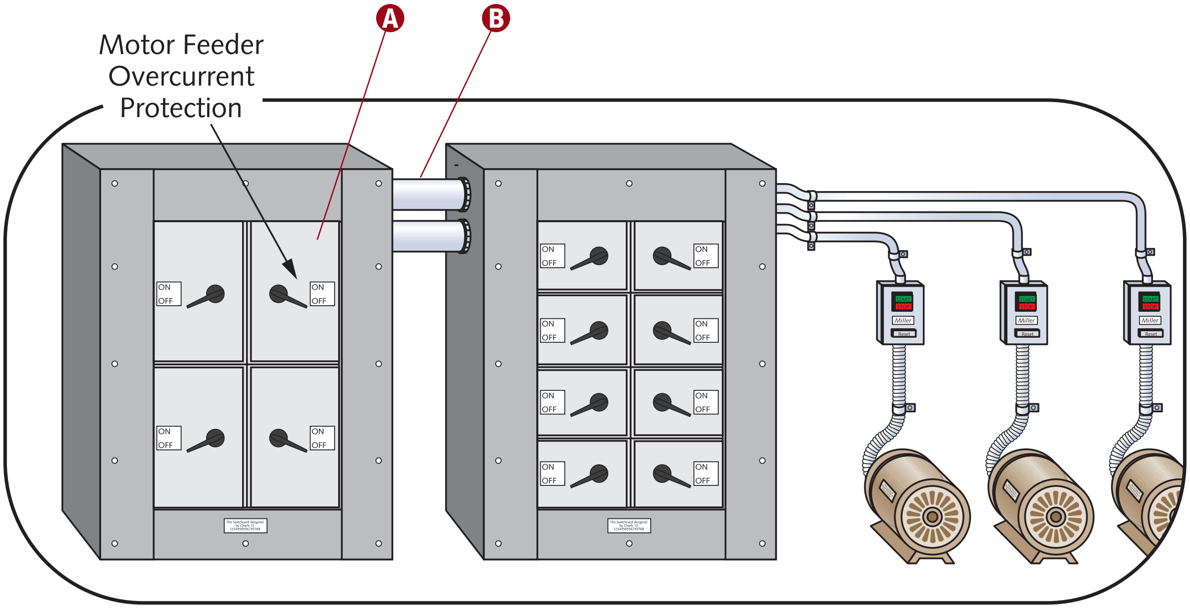
Ⓐ A feeder consisting of conductor sizes based on 430.24 that supplies a specific fixed motor load(s) shall have a protective device with a rating (or setting) no greater than the largest rating (or setting) of the branch-circuit short-circuit and ground-fault protective device for any motor supplied by the feeder (based on the maximum permitted value for the specific protective device in accordance with 430.52 or 440.22[A] for hermetic refrigerant motor compressors), plus the sum of the FLCs of the other motors in the group »*430.62(A)*«.

Ⓑ Article 430, Part V specifies devices for protection of feeder conductors supplying motors against overcurrents due to short circuits or ground-faults »*430.61*«.

Note

Where a feeder supplies a motor load and other load(s), the feeder protective device shall have a rating not less than that required for the sum of the other load(s) plus the following:

(1) For a single motor, the rating permitted by 430.52,
(2) For a single hermetic refrigerant motor compressor, the rating permitted by 440.22,
(3) For two or more motors, the rating permitted by 430.62 »*430.63*«.



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Specific Equipment

Cranes and Hoists

Conductors shall either be enclosed in raceways or be Type AC cable with insulated grounding conductor, Type MC cable, or Type MI cable, unless 610.11(A) through (E) otherwise permits »*610.11*«.

If a crane, hoist, or monorail hoist operates above readily combustible material, the resistors shall be located as outlined in 610.3(B)(1) and (2) »*610.3(B)*«.

Conductors shall comply with Table 310.4(1) unless otherwise permitted in 610.13(A) through (C) »*610.13*«.

Conductors exiting raceways/cables shall comply with 610.12(A) or (B) »*610.12*«.

Table 610.14(A) dictates the ampacities of conductors »*610.14(A)*«.

Where the secondary resistor and the controller are separate, calculate the minimum size conductors (between controller and resistor) by multiplying the motor secondary current by the appropriate Table 610.14(B) factor, and select a wire from Table 610.14(A) »*610.14(B)*«.

Motor and control external conductors shall not be smaller than 16 AWG, unless otherwise permitted in 610.14(C)(1) and (2) »*610.14(C)*«.

A disconnecting means with a continuous ampere rating not less than that calculated in 610.14(E) and (F) shall be provided between the runway contact conductors and the power supply. The disconnecting means shall comply with 430.109. This disconnecting means shall meet 610.31(1) through (4) provisions unless the exception is met »*610.31*«.

A disconnecting means in compliance with 430.109 shall be provided in the leads from the runway contact conductors or other power supply on all cranes and monorail hoists. The disconnecting means shall be lockable open in accordance with 110.25 »*610.32*«.

The continuous ampere rating of the switch or circuit breaker required by 610.32 shall not be less than 50% of the combined short-time ampere rating of the motors or not less than 75% of the sum of the short-time ampere rating of the motors required for any single motion »*610.33*«.

Each motor shall have an individual controller unless 610.51(A) or (B) allows otherwise »*610.51*«.

Ⓐ Article 610 covers electrical equipment and wiring installation for use with cranes, monorail hoists, hoists, and all runways »*610.1*«.

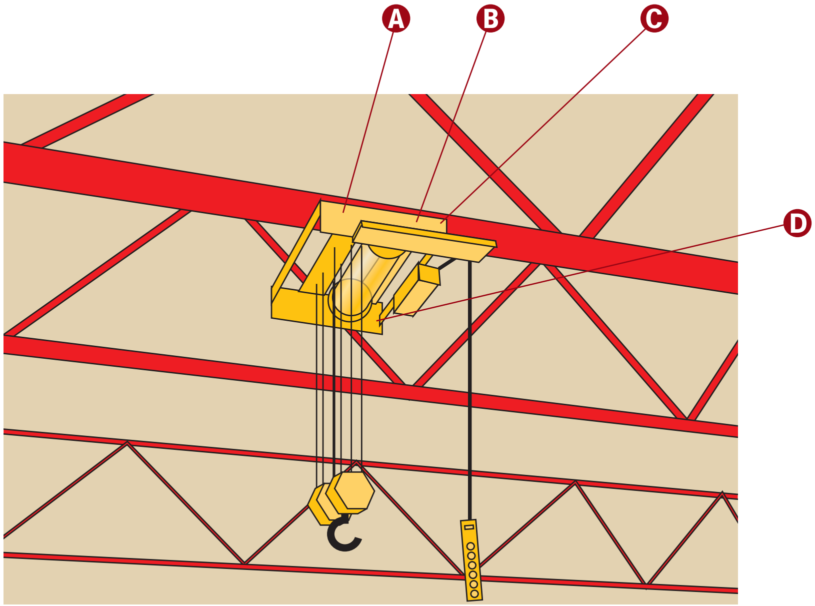
Ⓑ All exposed non-current-carrying metal parts of cranes, monorail hoists, hoists, and accessories, including pendant controls, shall be bonded either by mechanical connections or bonding jumpers, where applicable, so that the entire crane or hoist is an effective ground-fault current path by connection to the equipment grounding conductor of the branch circuit or feeder as required or permitted by Article 250, Parts I, V, VI, and VII. Moving parts, other than removable accessories, or attachments that have metal-to-metal bearing surfaces, shall be considered to be electrically bonded to each other through bearing surfaces for the purpose of establishing an effective ground-fault current path. The trolley frame and bridge frame shall not be considered as electrically bonded through the bridge and trolley wheels and its respective tracks. A separate bonding conductor shall be provided »*610.61*«.

Ⓒ Crane, hoist, and monorail hoist overload protection must comply with 610.43.

Ⓓ Crane, hoist, and monorail hoist motor branch circuits shall be protected by fuses or inverse-time circuit breakers that have a rating in accordance with Table 430.52(C)(1). Where two or more motors operate a single motion, the sum of their nameplate current ratings shall be considered as that of a single motor »*610.42(A)*«.

Note

All equipment operating in a hazardous (classified) location shall comply with Article 500 »***610.3(A)***«.



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Electric Welders

Each arc welder shall have overcurrent protection rated (or set) at no more than 200% of $I_{1\ \max}$. If the $I_{1\ \max}$ is not given, the overcurrent protection shall be rated (or set) at no more than 200% of the welder's rated primary current »*630.12(A)*«.

An overcurrent device is not required for an arc welder having supply conductors protected by an overcurrent device rated (or set) at no more than 200% of $I_{1\ \max}$, or the welder's rated primary current »*630.12(A)*«.

Supply conductors for an arc welder protected by an overcurrent device rated (or set) at no more than 200% of $I_{1\ \max}$ or rated primary welder current do not require a separate overcurrent device »*630.12(A)*«.

Ⓐ Minimum ampacity of arc welder conductors supplying a group of welders shall be based on individual currents determined in 630.11(A) as the sum of 100% of the two largest welders, plus 85% of the third largest welder, plus 70% of the fourth largest, plus 60% of all other welders »*630.11(B)*«.

Ⓑ Section 630.12(A) and (B) contain requirements for arc welder overcurrent protection. Where the resulting values do not correspond with 240.6 standard ampere ratings, or the rating or setting specified results in unnecessary opening of the overcurrent device, the next higher standard rating or setting is acceptable »*630.12*«.

Ⓒ Percentage values lower than provided in Table 630.11(B) are permitted in cases where the work is such that a high-operating duty cycle for individual welders is impossible »*630.11(B) Exception*«.

Ⓓ Supply conductor ampacity, for a single arc welder shall not be less than the $I_{1\ \text{eff}}$ value on the rating plate. If the $I_{1\ \text{eff}}$ is not given, the supply conductor ampacity shall meet 630.11(A) requirements »*630.11(A)*«.

Ⓔ Conductors supplying one or more arc welders shall have an overcurrent protective device rated (or set) not more than 200% of the conductor ampacity »*630.12(B)*«. (See 630.12[B] Informational Note for calculation explanation.)

Ⓕ Article 630 covers apparatus for electric arc welding, resistance welding, plasma cutting, and similar welding and cutting process equipment connected to an electric supply system »*630.1*«.

Ⓖ Conductors used in the secondary circuit of electric welders shall have flame-retardant insulation »*630.41*«.

Ⓗ Arc welders must have a rating plate giving the following information: name of manufacturer; frequency; number of phases; primary voltage; $I_{1\ \max}$ and $I_{1\ \text{eff}}$, or rated primary current; maximum open-circuit voltage; rated secondary current; and basis of rating, such as the duty cycle »*630.14*«.

Note

Resistance welders must comply with Article 630, Part III (630.31 through 630.34) provisions.

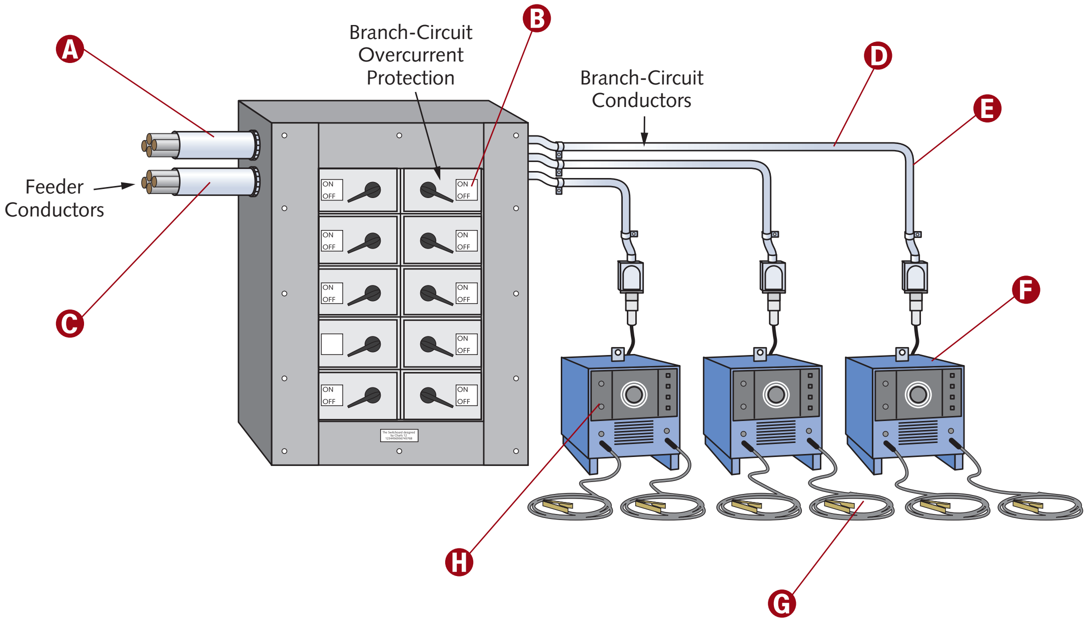
Note

A disconnecting means shall be provided in the supply circuit for each arc welder that is not equipped with a disconnect mounted as an integral part of the welder.

The disconnecting means shall be a switch, circuit breaker, or listed cord-and-plug connector, and its rating shall be not less than that necessary to accommodate overcurrent protection as specified under 630.12 ***»630.13«***.

Note

All 125-volt, 15- and 20-ampere receptacles for electrical hand tools or portable lighting equipment, supplied by single-phase branch circuits rated 150 volts or less to ground, installed in work areas where welders are operated shall have GFCI protection for personnel ***»630.8«***.



Electroplating

Equipment used in the electroplating process must be specifically identified for such service »*669.3*«.

Branch-circuit conductors supplying one or more units of equipment shall have an ampacity of at least 125% of the total connected load. Busbar ampacities shall meet 366.23 requirements »*669.5*«.

The following stipulations apply to conductors connecting the electrolyte tank equipment to the conversion equipment: (A) Insulated conductors can be run without insulated support, provided they are protected from physical damage. Bare copper (or aluminum) conductors are permitted where supported on insulators. (B) Insulated conductors can be run on insulated supports provided they are protected from physical damage. Bare copper (or aluminum) conductors are permitted where (1) supported on insulators and (2) guarded against accidental contact up to the termination point, per 110.27 »*669.6*«.

Where multiple power supplies serve the same dc system, the dc side of each power supply shall have a disconnecting means »*669.8(A)*«.

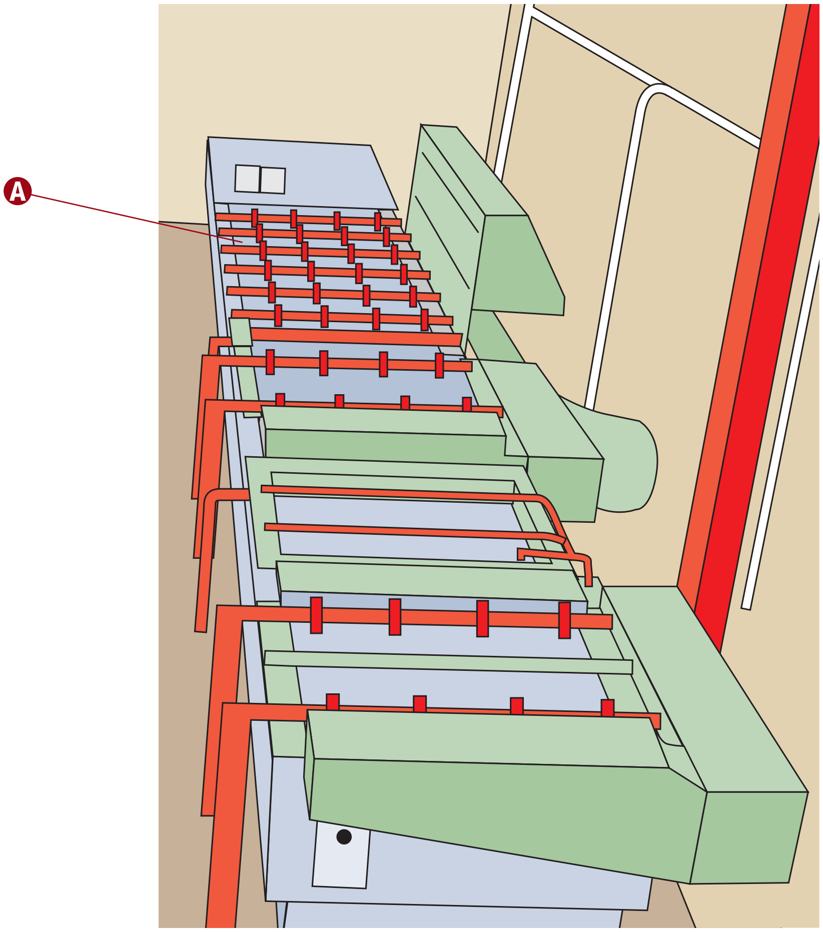
Removable links/conductors can serve as the disconnecting means »*669.8(B)*«.

Direct-current conductors shall be protected from overcurrent by at least one of the following: (1) fuses or circuit breakers, (2) a current-sensing device that operates a disconnecting means, or (3) other approved means »*669.9*«.

A Article 669 provisions apply to the installation of the electrical components and accessory equipment that supply the power and controls for electroplating, anodizing, electropolishing, and electrostripping, herein referred to simply as *electroplating* »669.1«.

Caution

Warning signs shall be posted to indicate the presence of bare conductors. The warning sign(s) or label(s) shall comply with 110.21(B) »*669.7*«.



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Industrial Machinery

A machine is considered to be an individual unit and, therefore, shall have a disconnecting means. The disconnecting means shall be permitted to be supplied by branch circuits protected by either fuses or circuit breakers. The disconnecting means is not required to incorporate overcurrent protection »*670.4(B)*«.

Where overcurrent protection (single circuit breaker or set of fuses) is furnished as part of the machine, 670.3 required markings shall be used and the supply conductors shall be considered either as feeders (or taps), as covered by 240.21 »*670.4(C)*«.

If the machine has no branch-circuit short-circuit and ground-fault protective device, the overcurrent protective device's rating (or setting) shall be based on 430.52 and 430.53, as applicable »*670.4(C)*«.

Where overcurrent protection is provided, per 670.4(C), the machine shall be marked "overcurrent protection provided at machine supply terminals" »*670.3(B)*«.

A Article 670 covers the nameplate data for, overvoltage protection for, and the size and overcurrent protection of supply conductors to industrial machinery »*670.1*«.

B The rating or setting of the overcurrent protective device for the circuit supplying the machine shall not be greater than the sum of the largest rating or setting of the branch-circuit short-circuit and ground-fault protective device provided with the machine, plus 125% of the full-load current rating of all resistance heating loads, plus the sum of the full-load currents of all other motors and apparatus that could be in operation at the same time »*670.4(C)*«.

C Article 110, Part II provisions apply to working space around electrical equipment operating at 1000 volts, nominal, or less to ground.

D The overcurrent protective device's rating (or setting) for the circuit supplying the machine must comply with 670.4(C).

E The selected supply conductor size shall have an ampacity not less than 125% of the FLC rating for all resistance heating loads, plus 125% of the highest rated motor's FLC rating, plus the sum of the FLC ratings of all other connected motors and apparatus, based on their duty cycle, that may be simultaneously operated »*670.4(A)*«.

F A permanent nameplate listing supply voltage, number of phases, frequency, FLC, maximum short-circuit and ground-fault protective device ampere rating, largest motor or load ampere rating, short-circuit rating of the machine industrial control panel based on the short-circuit current rating of a listed and labeled machine control enclosure or assembly or the short-circuit current rating established utilizing an approved method, and diagram number(s) shall be attached to the outside of or immediately adjacent to the main control equipment enclosure, remaining plainly visible after installation »*670.3(A)*«.

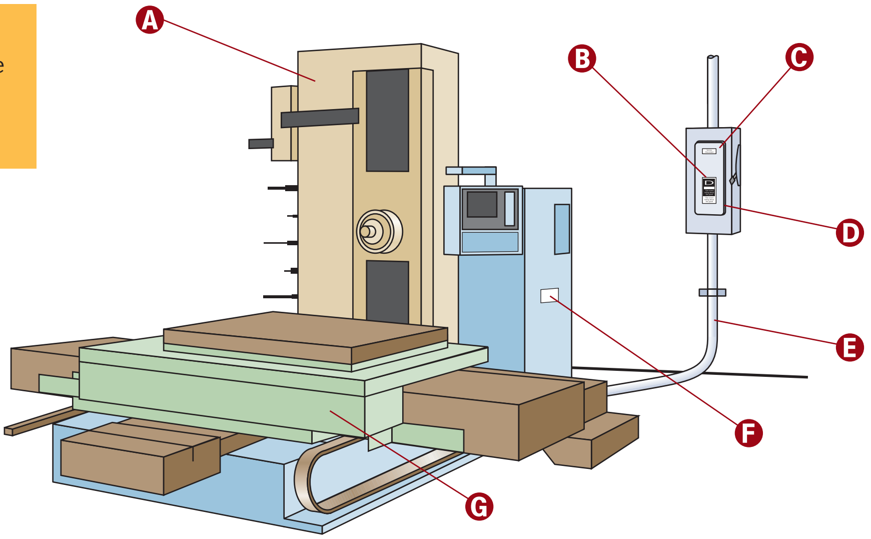
G **Industrial machinery (machine)** is defined as a power-driven machine (or a group of machines working together in a coordinated manner), not portable by hand while working, used to process material by cutting; forming; pressure; electrical, thermal, or optical techniques; lamination; or a combination of these processes. It can include associated equipment used to transfer material or tooling, including fixtures; assemble/disassemble; inspect; test; or package. (Associated electrical equipment, including logic controller[s] and associated software [or logic] together with the machine actuators and sensors, are all part of the industrial machine.) »*Article 100*«

Note

For information on the workspace requirements for equipment containing supply conductor terminals, see 110.26. For information on the workspace requirements for machine power and control equipment, see NFPA 79, *Electrical Standard for Industrial Machinery* ***»670.1 Informational Notes 2 and 3«***.

Warning

Industrial machinery shall not be installed where the available fault current exceeds its short-circuit current rating as marked in accordance with 670.3(A)(4) »*670.5(A)*«.



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Capacitors

Surge capacitors, or capacitors included as a component part of other apparatus and conforming with such apparatus' requirements, are excluded from Article 460 requirements »*460.1*«.

Capacitors containing more than 3 gallons (11 L) of flammable liquid shall be enclosed in vaults or outdoor fenced enclosures to comply with Article 110, Part III. This limit applies to any single unit in capacitor installations »*460.3(A)*«.

If a motor installation includes a capacitor connected on the load side of a motor overload device, the motor overload device's rating/setting shall be based on the improved power factor of the motor circuit. Disregard the capacitor effect in determining the motor-circuit conductor rating per 430.22 »*460.9*«.

A capacitor connected on the load side of a motor overload protective device does not require a separate overcurrent device »*460.8(B) Exception*«.

A separate disconnecting means is not required where a capacitor is connected on a motor controller's load side »*460.8(C) Exception*«.

A Each capacitor shall have a nameplate stating the manufacturer's name, rated voltage, frequency, kilovar or amperes, number of phases, and, if filled with a combustible liquid, the volume of liquid. Any nonflammable liquid filling shall be indicated on the nameplate. The nameplate shall also identify a capacitor having a discharge device inside the case »*460.12*«.

B Capacitors shall have a means of discharging stored energy »*460.6*«.

C Article 460 covers the installation of capacitors on electrical circuits »*460.1*«.

D Capacitor cases shall be connected to the equipment grounding conductor »*460.10*«. Capacitor cases shall not be connected to the equipment grounding conductor where capacitor units are supported on a structure designed to operate at other than ground potential »*460.10 Exception*«.

E Capacitor residual voltage shall be reduced to 50 volts, nominal, or less within 1 minute after the capacitor disconnects from the supply source »*460.6(A)*«. The discharge circuit shall either (1) be permanently connected to the capacitor/capacitor-bank terminals or (2) have automatic means of connecting it to the capacitor-bank terminals on line voltage removal. Manual means of switching or connecting the discharge circuit shall not be used »*460.6(B)*«.

F A disconnecting means shall be provided in each ungrounded conductor for each capacitor bank. The disconnecting means shall simultaneously open all ungrounded conductors. It can disconnect the capacitor from the line as a regular operating procedure. The rating of the disconnecting means shall be at least 135% of the capacitor's rated current »*460.8(C)*«.

G The capacitor circuit conductor's ampacity shall be at least 135% of the capacitor's rated current. The ampacity of the conductors that connect a capacitor to a motor's terminals, or to motor circuit conductors, shall not be less than one-third of the motor circuit conductor's ampacity and in no case less than 135% of the capacitor's rated current »*460.8(A)*«.

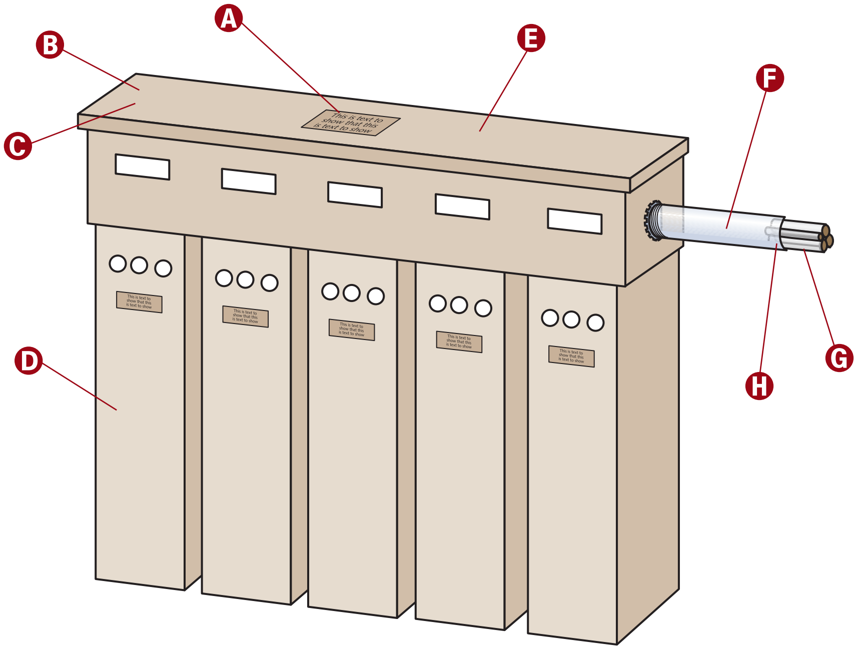
H An overcurrent device shall be provided in each ungrounded conductor for each capacitor bank. The overcurrent device's rating (or setting) shall be as low as practicable »*460.8(B)*«.

Note

Requirements for capacitors over 1000 volts, nominal, are in Part II (460.24 through 460.28).

Caution

Capacitors, accessible to unauthorized/unqualified persons, shall be enclosed, located, or guarded so that neither persons nor conducting materials can come into accidental contact with exposed energized parts, terminals, or associated buses. However, no additional guarding is required for enclosures accessible only to authorized, qualified persons »*460.3(B)*«.



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Summary

- A service may have up to six disconnecting means but the disconnecting means cannot be in a single panelboard.
- A service-entrance conductor's raceway shall not contain nonservice conductors.
- Conductors can be tapped, without overcurrent protection at the tap, to a feeder as specified in 240.21(B)(1) through (5).
- Conductors can connect to a transformer secondary, without overcurrent protection at the secondary, as specified in 240.21(C)(1) through (6).
- The provisions of 240.4(B) shall not be permitted for feeder taps or transformer secondary conductors.
- Article 450 covers not only transformers, but also includes transformer vault provisions.
- Taps can connect the grounding electrode conductors in a service consisting of more than a single enclosure.
- Cable tray provisions are located in Article 392.
- Article 430 covers motors, motor branch-circuit and feeder conductors (and their protection), motor overload protection, motor-control circuits, motor controllers, and motor-control centers.
- Article 610 covers electrical equipment and wiring installations used in connection with cranes, hoists, monorail hoists, and all runways.
- Electric arc welding, resistance welding apparatus, and similar welding equipment provisions are located in Article 630.
- Article 669 requirements apply to the installation of the electrical components and accessory equipment supplying electroplating, anodizing, electropolishing, and electrostripping power and controls.
- Article 670 covers the nameplate data for, overvoltage protection for, and the size and overcurrent protection of supply conductors to industrial machinery.
- Provisions pertaining to the installation of capacitors on electric circuits are contained in Article 460.

Unit 17 Competency Test

***NEC*® Reference** **Answer**

____________ ____________ 1. Terminals of motors and controllers shall be suitably marked or colored where necessary to indicate ____________.

____________ ____________ 2. Capacitors containing more than ____________ gallons of flammable liquid shall be enclosed in vaults or outdoor fenced enclosures complying with Article 110, Part III.

____________ ____________ 3. Cable tray systems shall not be used in ____________ or where subject to severe physical damage.

I. hoistways

II. hazardous locations

III. corrosive areas

a) I only b) I and II only c) I and III only d) I, II, and III

____________ ____________ 4. Wires that are used as crane (or hoist) contact conductors shall be secured at the ends by means of approved strain insulators and shall be mounted on approved insulators so that the extreme limit of displacement of the wire does not bring the latter within less than ____________ in. from the surface wired over.

____________ ____________ 5. Multispeed motors shall be marked with the code letter designating the locked-rotor kilovolt-ampere (kVA) per horsepower (hp) for the highest speed at which the motor ____________.

____________ ____________ 6. The walls and roofs of transformer vaults shall be constructed of materials that have approved structural strength for the conditions with a minimum fire resistance of ____________.

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***NEC*® Reference** **Answer**

____________ ____________ 7. The two to six service disconnecting means shall be permitted to consist of:

I. not more than six sets of circuit breakers mounted in a single enclosure

II. not more than six panelboards with a main service disconnecting means in each panelboard enclosure

a) I only b) II only c) both I and II d) neither I nor II

____________ ____________ 8. The residual voltage of capacitor rated 1000 volts or less shall be reduced to ____________, nominal, or less, within ____________ after the capacitor is disconnected from the source of supply.

____________ ____________ 9. The disconnecting means for motor circuits rated 1000 volts, nominal, or less, shall have an ampacity rating not less than ____________ of the full-load current rating of the motor.

____________ ____________ 10. Steel cable trays shall not be used as equipment grounding conductors for circuits with ground-fault protection above ____________.

____________ ____________ 11. Where no branch-circuit short-circuit and ground-fault protective device is provided with industrial machinery, the rating or setting of the overcurrent protective device shall be based on ____________, as applicable.

____________ ____________ 12. Branch-circuit conductors supplying one or more units of electroplating equipment shall have an ampacity of not less than ____________ of the total connected load.

____________ ____________ 13. Vaults containing more than ____________ transformer capacity shall be provided with a drain or other means that will carry off any accumulation of oil or water in the vault unless local conditions make this impracticable.

____________ ____________ 14. Conductors that supply one or more arc welders shall be protected by an overcurrent device rated or set at not more than ____________ of the conductor ampacity.

____________ ____________ 15. The full-load current of a 25-hp synchronous, 460-volt, 3-phase motor at unity power factor is ____________.

____________ ____________ 16. The ampacity of capacitor circuit conductors, rated 1000 volts or less, shall not be less than ____________ of the rated current of the capacitor.

____________ ____________ 17. Hoist and monorail hoist and their trolleys that are not used as part of an overhead traveling crane shall not require individual motor overload protection, provided the largest motor does not exceed ____________ and all motors are under manual control of the operator.

____________ ____________ 18. A door sill or curb that is of an approved height that will confine the oil from the largest transformer within a transformer vault shall be provided, and in no case shall the height be less than ____________ in.

____________ ____________ 19. Branch-circuit conductors that supply a single motor used in a continuous duty application shall have an ampacity of not less than ____________ of the motor full-load current rating as determined by 430.6(A)(1), or not less than specified in 430.22(A) through (G).

____________ ____________ 20. A(n) ____________ is a power-driven machine (or a group of machines working together in a coordinated manner), not portable by hand while working, that is used to process material by cutting; forming; pressure; electrical, thermal, or optical techniques; lamination; or a combination of these processes. It can include associated equipment used to transfer material or tooling, including fixtures, to assemble/disassemble, to inspect or test, or to package.

____________ ____________ 21. Cable trays containing welding cables shall have a permanent sign attached to the cable tray at intervals not greater than ____________ ft.

____________ ____________ 22. For raceways terminating at cable trays in supervised industrial facilities, a listed ____________ or adapter shall be used to securely fasten the raceway to the cable tray system.

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***NEC*® Reference**	**Answer**	
___________	___________	23. Where the motor-control circuit transformer rated primary current is less than 2 amperes, an overcurrent device rated or set at not more than ___________ of the rated primary current shall be permitted in the primary circuit.
___________	___________	24. For cranes and hoists, the dimension of the working space in the direction of access to live parts that are likely to require examination, adjustment, servicing, or maintenance while energized shall be a minimum of ___________ ft.
___________	___________	25. All transformer vault ventilation openings to the indoors shall be provided with automatic closing fire dampers that operate in response to a vault fire. Such dampers shall possess a standard fire rating of not less than ___________.
___________	___________	26. The ampacity of the supply conductors for a resistance welder that can be operated at different times, at different values of primary current, or duty cycle shall not be less than ___________ of the rated primary current for manually operated nonautomatic welders.
___________	___________	27. Cable trays shall be permitted to extend ___________ through partitions and walls, or ___________ through platforms and floors in wet or dry locations where the installations, complete with installed cables, are made in accordance with the requirements of 300.21.
___________	___________	28. Conductors for a motor used in a short-time, intermittent, periodic, or varying duty application shall have an ampacity of not less than the percentages of the motor nameplate current ratings shown in ___________, unless the authority having jurisdiction grants special permission for conductors of lower ampacity.
___________	___________	29. Each doorway leading into a transformer vault from the building interior shall be provided with a tight-fitting door that has a minimum fire rating of ___________.
___________	___________	30. ___________ shall be placed in all service-entrance motor-control centers to isolate service busbars and terminals from the remainder of the motor control center.
___________	___________	31. Crane, hoist, and monorail hoist motor branch circuits shall be protected by fuses or inverse-time circuit breakers that have a rating in accordance with ___________.
___________	___________	32. For a nonautomatically started motor, the overload protection shall be permitted to be shunted or cut out of the circuit during the starting period of the motor if the device by which the overload protection is shunted or cut out shall not be left in the starting position and if fuses or inverse-time circuit breakers rated or set at not over ___________ of the full-load current of the motor are located in the circuit so as to be operative during the starting period of the motor.
___________	___________	33. The discharge circuit of a capacitor bank rated 1000 volts or less shall not be connected in which way(s)? I. Permanently connected to the terminals II. Automatic means of connecting it to the terminals III. Manual means of connecting the discharge circuit a) I or II only b) I or III only c) III only d) I, II, or III
___________	___________	34. Each motor controller shall be capable of starting and stopping the motor it controls and shall be capable of interrupting the ___________ of the motor.
___________	___________	35. When a grounding terminal bar is required to be installed in a dry-type transformer enclosure, the terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any ___________ of the enclosure.
___________	___________	36. Tap conductors longer than 25 ft will be installed in a high-bay manufacturing building. The tap shall be made no less than ___________ ft from the floor.

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***NEC*® Reference**	**Answer**	
____________	____________	37. Service conductors will be connected in parallel and installed in two separate raceways. The ungrounded supply conductors in each of the two raceways will be 250-kcmil copper. A single supply-side bonding jumper will be installed to bond the two raceways. What minimum size copper conductor is required?
____________	____________	38. Circuit conductors other than service conductors shall not be installed in the same ____________ as the service conductors.
____________	____________	39. Feeder conductors will be connected in parallel and installed in two separate raceways. The ungrounded feeder conductors in each of the two raceways will be 500-kcmil copper. The overcurrent device protecting these feeder conductors will be an 800-ampere circuit breaker. Wire-type equipment grounding conductor will be installed in each of the two raceways. What minimum size copper equipment grounding conductor will be required in each raceway?
____________	____________	40. The service supplying power to a small industrial facility will consist of four disconnect switches. The disconnect switches will be separate enclosures with a main service disconnecting means in each enclosure. Each disconnect switch will be rated 225 amperes and the ungrounded service conductors supplying power to each disconnect switch will be 4/0 copper. A common grounding electrode conductor will be installed and a grounding electrode conductor tap will be installed from each disconnect switch to the common grounding electrode conductor. What size grounding electrode conductor tap is required from each disconnect switch to the common grounding electrode conductor?

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Unit 18

Section Five: Special Occupancies, Areas, and Equipment

Special Occupancies

Objectives

After studying this unit, the student should be able to:

- identify buildings or portions of buildings or structures termed *assembly occupancies*.
- explain the receptacle requirements for meeting rooms.
- define terms pertinent to theaters, audience areas of motion picture and television studios, performance areas, and similar locations.
- summarize theaters, audience areas of motion picture and television studios, performance areas, and similar location general requirements as well as stage switchboards, stage equipment, and theater dressing room provisions.
- explain how to locate provisions pertaining to carnivals, circuses, exhibitions, fairs, traveling attractions, and similar functions.
- clarify requirements for motion picture/television studios (and remote locations), including cellulose nitrate film storage vaults.
- explain motion picture projector provisions.
- explain in detail manufactured building requirements.
- clarify agricultural building provisions including what constitutes a bonding and equipotential plane.
- summarize requirements for mobile homes, manufactured homes, and mobile home parks.
- explain how to locate provisions relating to recreational vehicles and recreational vehicle parks.
- recall provisions for marinas and boatyards.
- clarify floating building requirements.

Introduction

Unit 18—Special Occupancies covers a variety of mostly unrelated occupancies. This unit addresses most of the occupancy types found in Article 518 through Article 555. Unlike other Chapter 5 articles in the *NEC*®, "Assembly Occupancies" (Article 518) is not a specific occupancy type. Assembly occupancies are buildings, or portions of buildings, designed (or intended) for the assembly of 100 or more persons. "Theaters, Audience Areas of Motion Picture and Television Studios, Performance Areas, and Similar Locations" (Article 520) covers all buildings, or that part of a building or structure, indoor or outdoor, designed for presentation, dramatic, musical, motion picture projection, or similar purposes; and specific audience seating areas within motion picture or television studios. "Carnivals, Circuses, Fairs, and Similar Events" (Article 525) addresses portable wiring and equipment installations for carnivals, circuses, exhibitions, fairs, traveling attractions, and similar functions, including wiring in and on all structures. Article 530, "Motion Picture and Television Studios and Remote Locations," requirements apply to motion picture and television studios in facilities and locations staffed by qualified persons, except as provided in 520.1. Such occupancies shall include those using either electronic or film cameras for image capture. Article 540, "Motion Picture Projection Rooms," provisions apply to motion picture projection rooms, motion picture projectors, and associated equipment (both professional and nonprofessional types) using incandescent, carbon arc, xenon, or other light source equipment that is known to develop hazardous gases, dust, or radiation. "Manufactured Buildings" (Article 545) details the requirements for manufactured buildings and building components. Article 547, "Agricultural Buildings," provisions apply to certain agricultural buildings, parts of buildings, and adjacent areas. Article 550, "Mobile Homes, Manufactured Homes, and Mobile Home Parks," requirements apply to the location types identified by the article's title. Article 551, "Recreational Vehicles and

Recreational Vehicle Parks," provisions apply to the electrical conductors and equipment installed within (or on) recreational vehicles, the conductors connecting recreational vehicles to an electrical supply, as well as the installation of equipment and devices related to electrical systems within a recreational vehicle park. Finally, Article 555 "Marinas, Boatyards, Floating Buildings, and Commercial and Noncommercial Docking Facilities" describes wiring and equipment installations in locations comprising fixed or floating piers, wharfs, docks, floating buildings, and other areas in marinas, boatyards, boat basins, boathouses, yacht clubs, boat condominiums, docking facilities associated with one-family dwellings, two-family dwellings, multifamily dwellings, and residential condominiums; any multiple docking facility or similar occupancies; and facilities that are used, or intended for use, for the purpose of repair, berthing, launching, storage, or fueling of small craft and the moorage of floating buildings.

Theaters, Audience Areas of Motion Picture and Television Studios, Performance Areas, and Similar Locations

General Requirements

The fixed wiring methods employed shall be metal raceway, nonmetallic raceway encased in 2 in. (50 mm) or more of concrete, Type MI cable, Type MC cable, or AC cable containing an insulated equipment grounding conductor sized per Table 250.122 »*520.5(A)*«.

Fixed wiring method stipulations in 640.9 apply to audio signal processing, amplification, and reproduction equipment; Parts I and IV of Article 800, Part IV of Article 805, and Part VI of Article 840 to communication circuits; and Part III of Article 725 to Class 2 and Class 3 remote control and signaling circuits; and Class 2 circuits that transmit power, data, or both to a powered device »*520.5(B)*«.

Portable switchboards, stage set lighting, stage effects, and other wiring without a fixed location is permitted with approved flexible cords and cables as provided elsewhere in Article 520. Such wiring shall not be fastened by uninsulated staples or nailing »*520.5(C)*«.

Nonmetallic-sheathed cable, Type AC cable, ENT, and PVC, can be installed where applicable building code does not require the building (or portions thereof) to be of fire-rated construction »*520.5(D)*«.

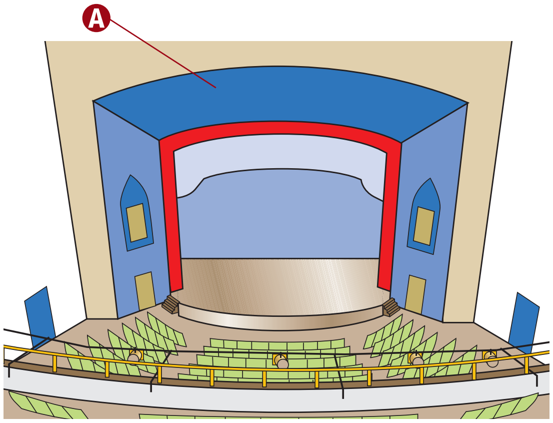
The number of conductors permitted in any metal conduit, PVC, or EMT for circuits, or for remote-control conductors, shall not exceed the percentage fill shown in Table 1 of Chapter 9. Where contained within an auxiliary gutter or wireway, the sum of the cross-sectional area of all internal conductors at any point shall not exceed 20% of the interior cross-sectional area of the auxiliary gutter or wireway. The 30-conductor limitation of 366.22 and 376.22 shall not apply »*520.6*«.

Caution

Any size branch circuit supplying receptacle(s) can also supply stage set lighting. The receptacle's voltage rating shall not be less than the circuit voltage. Receptacle ampere rating and branch-circuit conductor ampacity shall at least equal the branch-circuit overcurrent device ampere rating. Table 210.21(B)(2) and 210.23 shall not apply. The requirements in 210.8(B) other than 210.8(B)(6) shall apply »*520.9*«.

Portable stage/studio lighting equipment and portable power distribution equipment not identified for outdoor use shall be permitted for temporary outdoor use, provided the equipment is (1) supervised by qualified personnel while energized and (2) barriered from the general public »*520.10*«.

Ⓐ Article 520 covers all buildings/structures, or parts thereof, indoor or outdoor, intended for presentation, dramatic, musical, motion picture projection, or similar purposes as well as specific audience seating areas within motion picture or television studios »*520.1*«.



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Definitions

Ⓐ **Border light:** A permanently installed overhead strip light »*Article 100*«.

Ⓑ Breakout assemblies can contain listed, hard usage (junior hard service) cords where all of the following conditions are met:

1. The cords connect a single multipole connector (containing two or more branch circuits) and multiple 2-pole, 3-wire connectors.
2. No cord in the breakout assembly exceeds 20 ft (6.0 m) in length.
3. The breakout assembly's entire length is protected from physical damage by attachment to a pipe, truss, tower, scaffold, or other substantial support structure.
4. All branch circuits feeding the breakout assembly are protected by overcurrent devices rated at no more than 20 amperes »*520.68(A)(6)*«.

Ⓒ **Breakout assembly:** An adapter used to join a multipole connector (containing two or more branch circuits) to multiple individual branch-circuit connectors »*Article 100*«.

Ⓓ **Portable equipment:** Equipment intended for movement from place to place and fed with portable cords or cables »*Article 100*«.

Ⓔ Flexible conductors, including cable extensions, supplying portable stage equipment shall be listed extra-hard usage cords or cables »*520.68(A)(1)*«.

Ⓕ **Connector strip:** A metal wireway containing pendant or flush receptacles »*Article 100*«.

Ⓖ **Footlight:** A border light installed on (or in) the stage »*Article 100*«.

Ⓗ **Portable power distribution unit:** A power distribution box containing receptacles and overcurrent devices »*Article 100*«.

Ⓘ Portable power distribution units shall comply with (a) and (b):

(a) Portable power distribution units shall be listed.

(b) Portable power distribution equipment fed by single-conductor feeder systems shall comply with the requirements of 520.53(C) and (D) and 520.54. »*520.62*«.

Ⓙ **Proscenium:** The wall and arch separating the stage from the auditorium (house) »*Article 100*«.

Ⓚ **Stand lamp (work light):** A portable stand containing a general-purpose luminaire or lampholder with guard for stage or auditorium general illumination »*Article 100*«.

Ⓛ **Strip light:** A luminaire with a row of multiple lamps »*Article 100*«.

Ⓜ **Two-fer:** An assembly containing one male plug and two female cord connectors used to join two loads to one branch circuit »*Article 100*«.

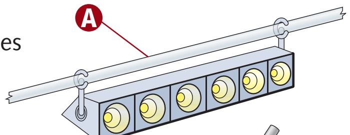
Ⓝ Adapters, two-fers, and other single/multiple circuit outlet devices shall comply with all of the following:

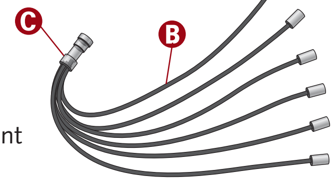
(a) Each receptacle and corresponding cable shall have the same current and voltage rating as its supply plug. Utilization in a stage circuit having a greater current rating is not allowed.

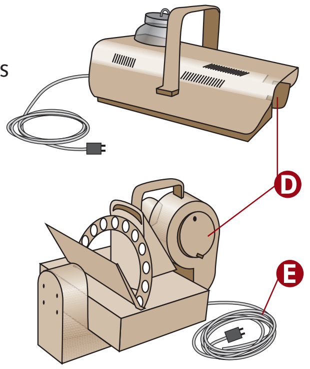
(b) All connectors shall be wired in accordance with 520.67.

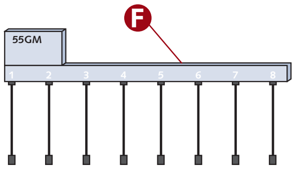
(c) Adapter and two-fer conductors shall be listed extra-hard usage or listed hard usage (junior hard service) cord. The overall length of hard usage (junior hard service) cord is restricted to 6.6 ft (2.0 m) »*520.69*«.

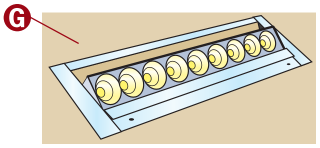
Ⓞ Stand lamps can be supplied by listed, hard usage cord provided the cord is not subject to physical damage and is protected by an overcurrent device rated at not over 20 amperes »*520.68(A)(3)*«.

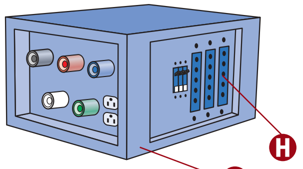


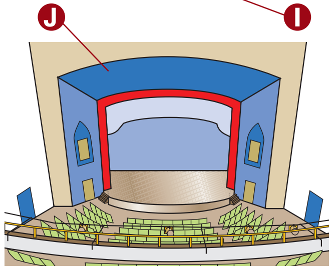


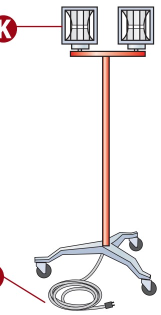


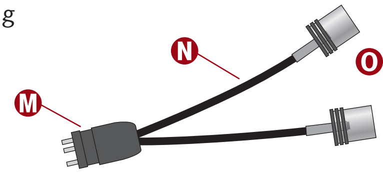


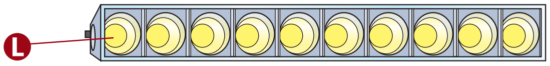












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Fixed Stage Switchboards

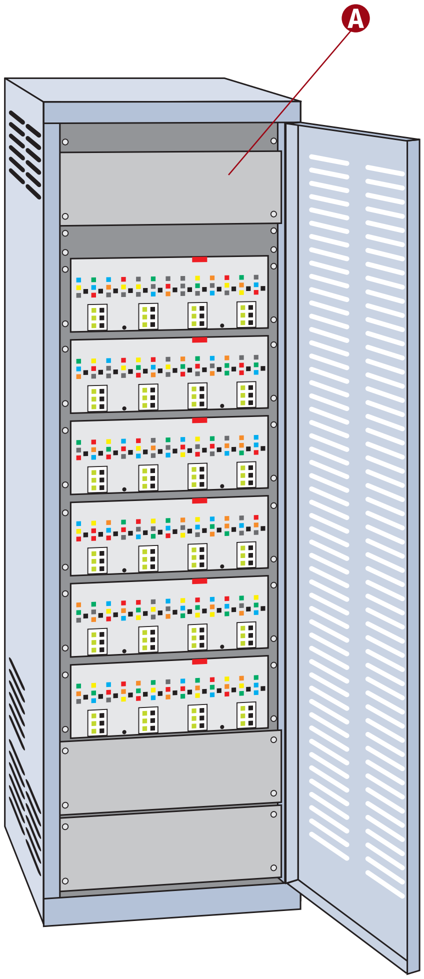
Fixed stage switchboards shall comply with 520.21(1) through (5):

(1) Fixed stage switchboards shall be listed.
(2) Fixed stage switchboards shall be readily accessible but shall not be required to be located on or adjacent to the stage. Multiple fixed stage switchboards shall be permitted at different locations.
(3) A fixed stage switchboard shall contain overcurrent protective devices for all branch circuits supplied by that switchboard.
(4) A fixed stage switchboard shall be permitted to supply both stage and non-stage equipment.
(5) A fixed stage switchboard shall comply with the marking and work space requirements in 408.18(C), but shall not be required to comply with the load terminal location requirements in 408.18(C)(1), (2), and (3) »*520.21*«.

If dimmers are installed in ungrounded conductors, each dimmer shall have overcurrent protection no greater than 125% of the dimmer rating and shall be disconnected from all ungrounded conductors where the dimmer's master or individual switch (or circuit breaker) is in the open position »*520.25(A)*«.

A stage switchboard shall be one (or a combination) of the following types:

(A) Manual. Dimmers and switches operated by handles mechanically linked to control devices.
(B) Remotely Controlled. Devices operated electrically from a pilot-type control console or panel. Pilot control panels can be part of the switchboard or can be located elsewhere.
(C) Intermediate. A stage switchboard having interconnected circuits is a secondary switchboard (patch panel) or panelboard remote to the primary stage switchboard and shall contain overcurrent protection. If the dimmer panel provides the required branch-circuit overcurrent protection, it can be omitted from the intermediate switchboard.
(D) Constant Power. A stage switchboard containing only overcurrent protective devices and no control elements »*520.26*«.



Stage switchboard supply feeders shall be one of the following:

1. **A single feeder disconnected by a single disconnect device.**
2. **Unlimited feeder quantities are permitted, provided all feeders are part of a single system. Where combined, neutral conductors in a given raceway shall have sufficient ampacity to carry the maximum unbalanced current supplied by multiple feeder conductors within the same raceway. It is not necessary that the ampacity be greater than that of the neutral conductor supplying the primary stage switchboard. Parallel neutral conductors shall comply with 310.10(G).**
3. **Separate feeders of a single primary stage switchboard shall each have a disconnecting means. The primary stage switchboard shall be permanently and conspicuously labeled with the number and location of disconnecting means. If the disconnecting means are located in multiple distribution switchboards, the primary stage switchboard shall have barriers corresponding with these multiple locations »*520.27(A)*«.**

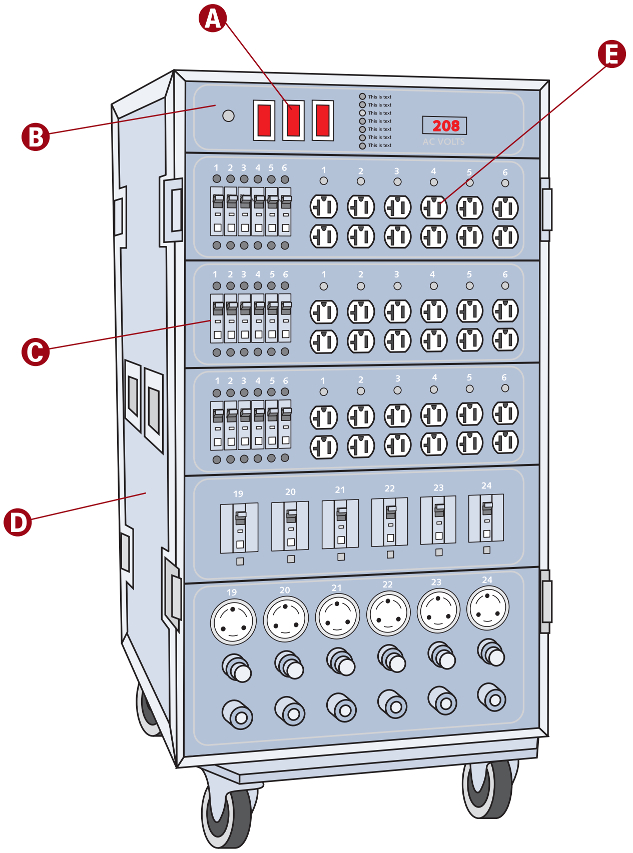
When calculating supply capacity to switchboards, it is permissible to consider the maximum intended switchboard load in a given installation provided that (1) all switchboard supply feeders are protected by an overcurrent device with a rating no greater than the feeder's ampacity and (2) opening the overcurrent device does not affect proper operation of egress or emergency lighting systems »*520.27(C)*«.

A A fixed stage switchboard is a permanently installed switchboard, panelboard, or rack containing dimmers or relays with associated overcurrent protective devices, or overcurrent protective devices alone, used primarily to feed stage equipment »*Article 100*«.

Note

For the purpose of ampacity adjustment, the following shall apply:
(1) The neutral conductor of feeders supplying solid-state, phase-control 3-phase, 4-wire dimming systems shall be considered a current-carrying conductor.
(2) The neutral conductor of feeders supplying solid-state, sine wave 3-phase, 4-wire dimming systems shall not be considered a current-carrying conductor.
(3) The neutral conductor of feeders supplying systems that use or may use both phase-control and sine wave dimmers shall be considered as current-carrying »*520.27(B)*«.

Portable Switchboards on Stage



Although portable switchboards shall contain overcurrent protection for branch circuits, the requirements of 210.23 shall not apply »*520.52*«.

With the exception of busbars, all conductors within the switchboard shall be stranded »*520.53(E)*«.

Only listed extra-hard usage cords or cables shall be permitted to supply a portable stage switchboard. The supply cords (or cable) shall terminate within the switchboard enclosure, in an externally operable fused master switch, circuit breaker, or an identified connector assembly. The supply cords or cable (and connector assembly) shall have current ratings not less than the total load connected to the switchboard and shall be protected by overcurrent devices »*520.54(A)*«.

Single-pole portable cable connectors, where used, shall be listed and of the locking type »*520.54(I)*«.

A A pilot light shall be provided for each ungrounded conductor feeding the switchboard. The pilot light(s) shall be connected to the incoming feeder so that operation of the main overcurrent protective device or master switch shall not affect the operation of the pilot light(s) »*520.53(A)*«.

B Portable stage switchboards shall be listed and shall comply with 520.53(A) through (E) »*520.53*«.

C Portable switchboards shall contain overcurrent protection for branch circuits. The requirements of 210.23 shall not apply »*520.52*«.

D A portable stage switchboard is defined as a portable rack or pack containing dimmers or relays with associated overcurrent protective devices, or overcurrent protective devices alone that are used to feed stage equipment »*Article 100*«.

E **Road show connection panel (a type of patch panel):** A panel designed to allow for road show connection of portable stage switchboards to fixed lighting outlets via permanently installed supplementary circuits. The panel, supplementary circuits, and outlets shall comply with all of the following:

(a) Circuits shall originate from grounding-type polarized inlets whose current and voltage rating match the fixed-load receptacles.

(b) Circuits transferred between fixed and portable switchboards shall transfer all circuit conductors simultaneously.

(c) Supplementary circuit supply devices shall have branch-circuit overcurrent protection. Each supplementary circuit, within the road show connection panel and theater, shall be protected by branch-circuit overcurrent protective devices installed within the road show connection panel.

(d) Panel construction shall be in accordance with Article 408 »*520.50*«.

Note

Where paralleled sets of current-carrying, single-pole separable connectors are provided as input devices for portable stage switchboards, they shall be prominently labeled with a warning indicating the presence of internal parallel connections »***520.53(C)***«.

Caution

Unless an exception is met, only qualified persons can route portable supply conductors, make/break supply connectors (and other supply connections), and energize/de-energize supply services. The portable switchboard shall, by means of permanent and conspicuous markings, reflect this requirement »*520.54(K)*«.

Note

Where connectors are used in a supply conductor, there shall be a maximum number of three interconnections (mated connector pairs) where the total length from supply to switchboard does not exceed 100 ft (30 m). Should the total length from supply to switchboard exceed 100 ft (30 m), one additional supply conductor interconnection is permitted for each additional 100 ft (30 m) supply conductor »***520.54(H)***«.

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Stage Equipment Other than Switchboards

Arrange footlights, border lights, and proscenium sidelights so that no branch circuit supplying such equipment carries more than a 20-ampere load »*520.41(A)*«.

Article 210 provisions can be applied to heavy-duty lampholder circuits »*520.41(B)*«.

The conductors for foot, border, proscenium, or portable strip lights and connector strips shall have insulation suitable for the conductor's operating temperature, but in no case less than 125°C (257°F). The ampacity of the 125°C (257°F) conductors shall be that of 60°C (140°F) conductors »*520.42*«.

All drops from connector strips shall be 90°C (194°F) wire sized to the ampacity of 60°C (140°F) cords and cables, with no more than 6 in. (150 mm) of conductor extending into the connector strip. Section 310.15(C)(1) shall not apply »*520.42*«.

The ampacity of listed multiconductor extra-hard usage type cords and cables not in direct contact with equipment containing heat-producing elements can be determined by Table 520.44(C)(2)(1). If so determined, the maximum load current in any conductor shall not exceed the values in Table 520.44(C)(2)(1) »*520.44(C)(2)*«.

Receptacles for on-stage electrical equipment shall be rated in amperes. Conductors supplying receptacles shall comply with Articles 310 and 400 »*520.45*«.

Connector strip, drop box, floor pocket, and similar receptacles used to connect portable stage-lighting equipment shall be pendant, or mounted in suitable pockets or enclosures, and shall satisfy 520.45 requirements. Connector strip and drop box supply cables shall meet 520.44(C) specifications »*520.46*«.

Bare-bulb lamps in backstage and ancillary areas, where contact with scenery is possible, shall be located and guarded to remain free from physical damage. A minimum air space of at least 2 in. (50 mm) between such lamps and any combustible material shall be provided »*520.47*«. For the purpose of this section, decorative lamps installed in scenery shall not be considered to be backstage lamps »*520.47 Exception*«.

The operating circuit of an electrical device releasing stage smoke ventilators shall be (1) normally closed and (2) controlled by at least two externally operable switches with one such switch being readily accessible on stage and the other positioned as dictated by the AHJ. The device shall be designed for the connected circuit's full voltage, with no resistance inserted. The device shall be enclosed in a suitable metal box with a door that shall remain closed except during service to the equipment »*520.49*«.

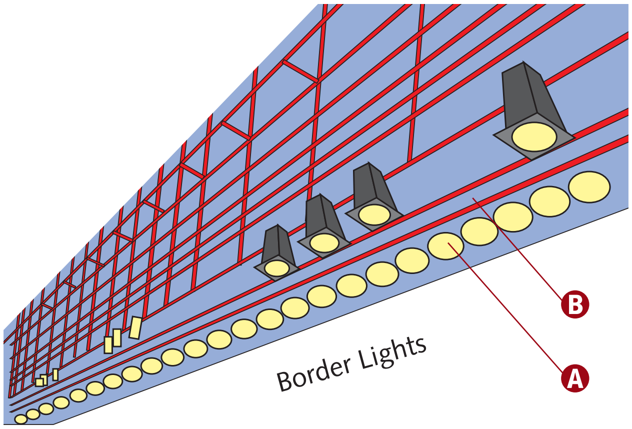
A Borders and proscenium sidelights shall be (1) constructed per 520.43 specifications, (2) suitably stayed and supported, and (3) designed so that the reflector flanges (or other adequate guards) protect the lamps from mechanical damage and from accidental contact with scenery or any combustible material »*520.44(A)*«.

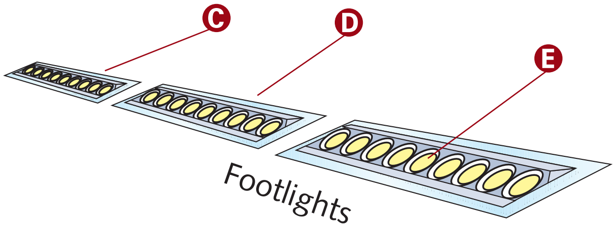
B Cords and cables for the supply to border lights, drop boxes, and connector strips shall be listed for extra-hard usage and shall be suitably supported. Such cords and cables shall be employed only where flexible conductors are necessary. Conductor ampacity shall satisfy 400.5 provisions »*520.44(C)(1)*«.

C Where the metal trough construction specified in 520.43(A) is not used, footlights shall consist of individual outlets whose lampholders are wired with RMC, IMC, FMC, Type MC cable, or mineral-insulated metal-sheathed cable. The circuit conductors shall be soldered to the lampholder terminals »*520.43(B)*«.

D The current supply to disappearing footlights shall automatically disconnect when the footlights are fully retracted »*520.43(C)*«.

E Metal trough footlights containing circuit conductors shall be made of oxidation-resistant sheet metal no lighter than 0.032 in. (0.81 mm). Lampholder terminals shall be spaced at least ½ in. (13 mm) from the metal trough. The circuit conductors shall be soldered to the lampholder terminals »*520.43(A)*«.





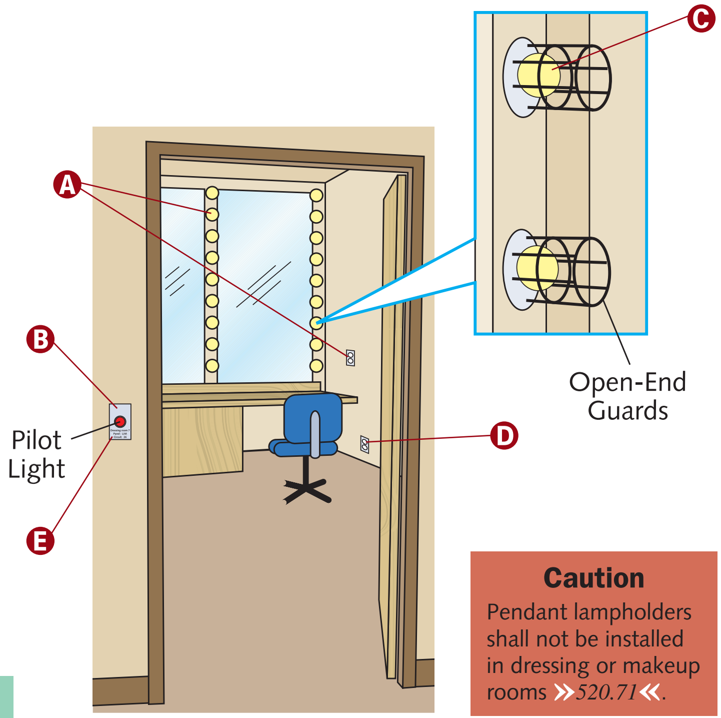
Theater Dressing Rooms, Dressing Areas, and Makeup Areas

A All dressing or makeup room luminaires, lampholders, and receptacles adjacent to the mirror(s) and above the dressing or makeup counter(s) shall be controlled by wall switches installed in the dressing or makeup room(s) »*520.73*«.

B Each switch required in 520.73 shall be provided with a pilot light located outside of and adjacent to the door of the room being controlled to indicate when the circuit is energized. Pilot lights shall be neon, LED, or other extended-life lamp. Pilot lights shall be recessed or provided with a mechanical guard »*520.74*«. Note: Although the pilot light must be installed outside the dressing room, the switch must be located inside the dressing room.

C All exposed lamps in dressing or makeup areas including rooms where they are less than 8 ft (2.5 m) from the floor shall be equipped with open-end guards riveted to the outlet box cover or otherwise sealed and locked in place. Recessed lamps shall not be required to be equipped with guards »*520.72*«.

D Other outlets installed in the dressing or makeup rooms shall not be required to be switched »*520.73*«.



Caution

Pendant lampholders shall not be installed in dressing or makeup rooms »*520.71*«.

Note

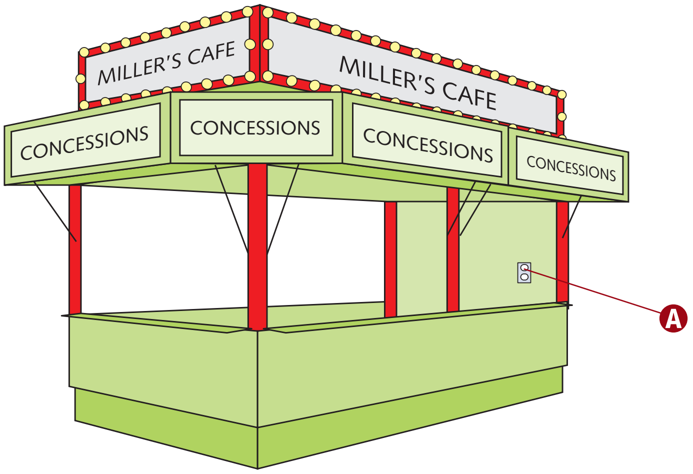
Fixed wiring in motion picture and television studio dressing rooms shall be installed according to Chapter 3 methods »***530.61***«. (Sections 520.71 through 520.74 provisions apply only to theater dressing rooms, and not to motion picture and television studio dressing rooms.)

Carnivals, Circuses, Fairs, and Similar Events

Ground-Fault Circuit-Interrupter (GFCI) Protection

Egress lighting shall not be protected by a GFCI »*525.23(C)*«.

A In addition to the requirements of 210.8(B), GFCI protection for personnel shall be provided for the following: (1) all 125-volt, single-phase, 15- and 20-ampere non-locking type receptacles used for disassembly/reassembly or readily accessible to the general public and (2) equipment that is readily accessible to the general public and supplied from a 125-volt, single-phase, 15- or 20-ampere branch circuit. The GFCI can be an integral part of the attachment plug or located in the power-supply cord within 12 in. (300 mm) of the attachment plug. Listed cord sets incorporating GFCI for personnel shall be permitted »*525.23(A)*«.



Note

Receptacles that are not accessible from grade level and only facilitate quick disconnecting/reconnecting of electrical equipment do not require GFCI protection. These receptacles shall be of the locking type »***525.23(B)***«.

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General Requirements

Attractions utilizing pools, fountains, and similar installations containing water must be installed in accordance with the requirements of Parts I, II, III, and V of Article 680 »*525.3(B)*«.

The following equipment connected to the same source shall be bonded: (1) metal raceways and metal-sheathed cable; (2) metal enclosures of electrical equipment; and (3) metal frames and metal parts of portable structures, trailers, trucks, or other equipment that contain or support electrical equipment. Where the metal frames or parts of the equipment in 525.30(1), (2), or (3) are likely to become energized in the event of a fault, the equipment grounding conductor of the supply circuit shall be permitted to serve as the bonding means »*525.30*«.

Flexible cords or cables accessible to the public shall be arranged to minimize the tripping hazard and can be covered with nonconductive matting secured to the walkway surface or protected with another approved cable protection method, provided that the matting or other protective method does not constitute a greater tripping hazard than the uncovered cables. Burying cables shall be permitted and the requirements of 300.5 shall not apply »*525.20(G)*«.

No amusement ride, attraction, tent, or similar structure shall support wiring for any other ride or structure unless specifically designed for that purpose »*525.20(F)*«.

The equipment grounding conductor shall be connected to the system grounded conductor at the service disconnecting means or, in the case of a separately derived system such as a generator, at the generator or first disconnecting means supplied by the generator »*525.31*«.

The continuity of the equipment grounding conductor shall be verified each time that portable electrical equipment is connected »*525.32*«.

Ⓐ Conductors shall have a vertical clearance to ground per 225.18. These clearances apply only to exterior wiring of tents and concessions (not within) »*525.5(A)*«.

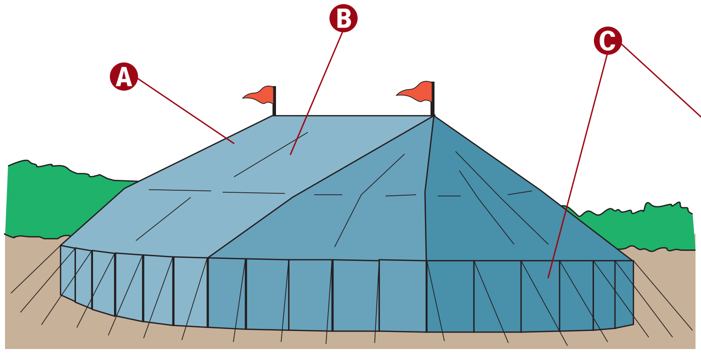
Ⓑ Tent and concession interior electrical wiring for temporary lighting shall be securely installed and mechanically protected where subject to physical damage. Protect all temporary general illumination lamps from accidental breakage by installing a suitable luminaire or lampholder with a guard »*525.21(B)*«.

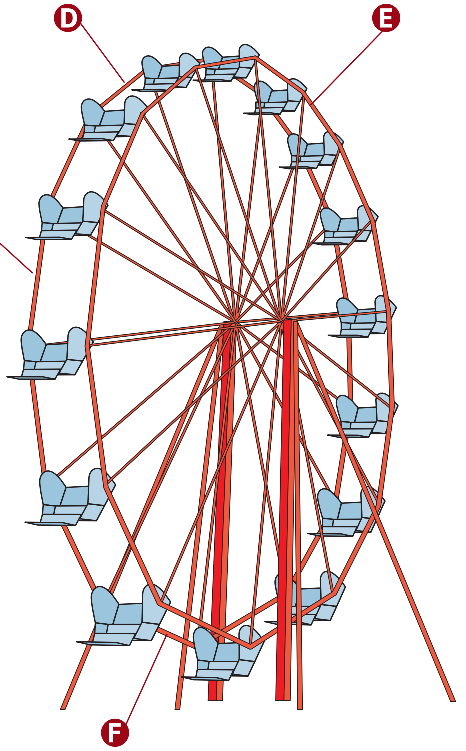
Ⓒ Article 525 covers the installation of portable wiring and equipment for carnivals, circuses, fairs, and similar functions, including wiring in or on all structures »*525.1*«.

Ⓓ Portable structures shall be maintained not less than 15 ft (4.5 m) in any direction from overhead conductors operating at 600 volts or less, except for the conductors supplying the portable structure. Portable structures included in 525.3(B) shall comply with Table 680.9(A) »*525.5(B)(1)*«.

Ⓔ Electrical equipment and wiring methods in or on portable structures shall be provided with mechanical protection where such equipment or wiring methods are subject to physical damage »*525.6*«.

Ⓕ A means to disconnect each portable structure from all ungrounded conductors shall be provided. The disconnecting means shall be located within sight of and within 6 ft (1.8 m) of the operator's station. The disconnecting means shall be readily accessible to the operator, including when the ride is in operation. If accessible to unqualified persons, the disconnecting means shall be lockable. A shunt trip device that opens the fused disconnect or circuit breaker if a switch located in the ride operator's console is closed shall be a permissible method of opening the circuit »*525.21(A)*«.





Warning

Portable structures shall not be located under or within a space that is located 15 ft (4.5 m) horizontally and extending vertically to grade of conductors operating in excess of 600 volts »*525.5(B)(2)*«.

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Assembly Occupancies

Comprehensive Provisions

The wiring of any such building or structure, or portion of a building or structure, containing a projection booth, stage platform, or area for the presentation of theatrical or musical productions (fixed or portable) shall comply with Article 520. These requirements also apply to associated audience seating and all equipment used in the production, including portable equipment and associated wiring that is not connected to permanent wiring »*518.2(C)*«.

The fixed wiring methods shall be metal raceways, flexible metal raceways, nonmetallic raceways encased in not less than 2 in. (50 mm) of concrete, Type MI, MC, or AC cable. The wiring method shall itself qualify as an equipment grounding conductor according to 250.118 or shall contain an equipment grounding conductor sized in accordance with Table 250.122 »*518.4(A)*«.

ENT and PVC are not approved for use in other spaces used for environmental air in accordance with 300.22(C) »*518.4(D)*«.

Portable switchboards, portable power distribution equipment, and commercial appliance outlet centers shall be installed as follows: (1) overcurrent protection shall be provided; (2) overcurrent devices, power outlets, and commercial appliance outlet centers shall not be accessible to the general public; (3) means for connecting an equipment grounding conductor shall be provided; (4) power outlets and commercial appliance outlet centers shall be marked as specified in 518.5(A)(4); (5) panelboard(s) installed in a listed commercial appliance outlet center designed for in-floor mounting shall be permitted to be installed in the face-up position if listed appropriately and 408.43 shall not apply; (6) portable switchboards and portable power distribution equipment shall be supplied only from listed power outlets or listed commercial appliance outlet centers, each having sufficient voltage and current ratings; and (7) the neutral conductor of feeders supplying solid-state phase control, 3-phase, 4-wire dimming systems shall be considered a current-carrying conductor for purposes of ampacity adjustment. The neutral conductor of feeders supplying solid-state sine wave, 3-phase, 4-wire dimmer systems shall not be considered a current-carrying conductor for purposes of ampacity adjustment »*518.5*«.

Ⓐ Temporary wiring for display booths within exhibition halls (as in trade shows) shall be permitted to be installed in accordance with Article 590. Flexible cables and cords, approved for hard or extra-hard usage, laid on floors shall be protected from contact by the general public. The GFCI requirements of 590.6 shall not apply. All other GFCI requirements of the *NEC* shall apply.

Where GFCI protection for personnel is supplied by plug and cord connection to the branch circuit or to the feeder, the GFCI protection shall be listed as portable GFCI protection or provide a level of protection equivalent to a portable GFCI, whether assembled in the field or at the factory »*518.3*«.

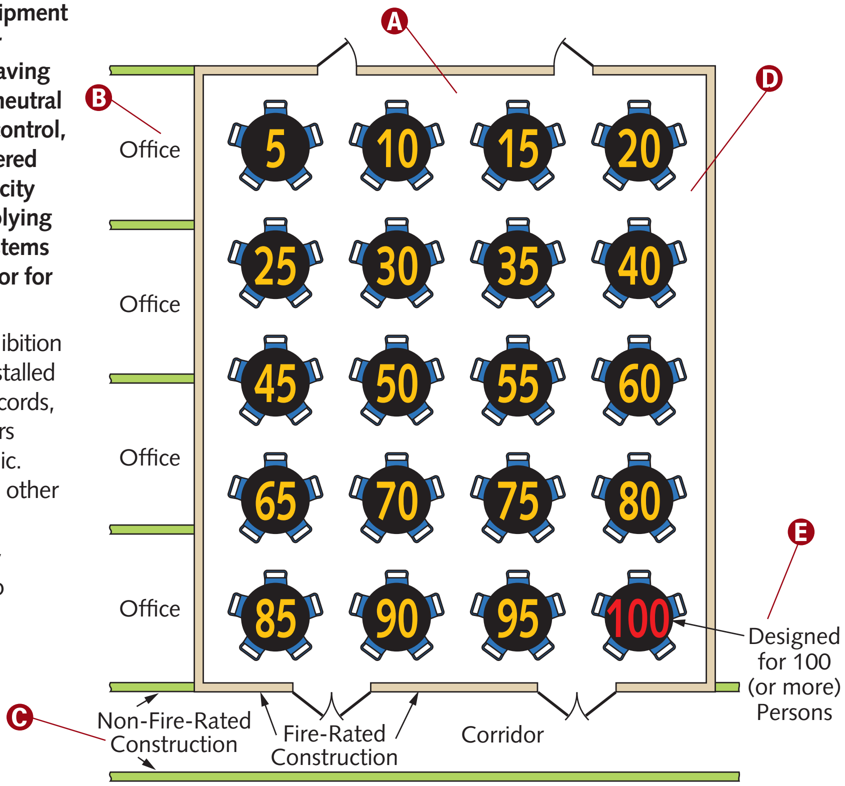
Ⓑ Where an assembly occupancy forms a portion of a building containing other occupancies, Article 518 applies only to that portion of the building considered an assembly occupancy. Occupancy of any room or space for assembly purposes by less than 100 persons in a building of other occupancy, and incidental to such other occupancy, shall be classified as part of the other occupancy »*518.2(B)*«.

Ⓒ In addition to the wiring methods of 518.4(A), nonmetallic-sheathed cable, Type AC cable, ENT, and PVC can be installed in those buildings (or portions thereof) for which the applicable building code does not require fire-rated construction »*518.4(C)*«.

Ⓓ ENT and PVC can be installed within club rooms, conference and meeting rooms in hotels (or motels), courtrooms, dining facilities, restaurants, mortuary chapels, museums, libraries, and places of religious worship where:

1. The ENT or PVC is concealed within walls, floors, and ceilings where the enclosing structure provides a thermal material barrier having at least a 15-minute finish rating as identified in fire-rated assembly listings.
2. Such tubing or conduit is installed above suspended ceilings where the ceilings act as a thermal material barrier having at least a 15-minute finish rating according to fire-rated assembly listings »*518.4(D)*«.

Ⓔ Except for the assembly occupancies explicitly covered by 520.1, this article covers all buildings or portions of buildings or structures designed or intended for the gathering together of 100 or more persons for such purposes as deliberation, worship, entertainment, eating, drinking, amusement, awaiting transportation, or similar purposes »*518.1*«.



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Meeting Rooms

For the purposes of 210.65(A), meeting rooms are typically designed or intended for the gathering of seated occupants for such purposes as conferences, deliberations, or similar purposes, where portable electronic equipment such as computers, projectors, or similar equipment is likely to be used »*210.65(A) Informational Note No. 1*«.

Note

The following are the requirements stated in 210.52(A)(1) through (A)(4):

(1) Receptacles shall be installed such that no point measured horizontally along the floor line of any wall space is more than 6 ft (1.8 m) from a receptacle outlet.

(2) As used in 210.52(A), a wall space shall include the following:

- (1) Any space 2 ft (600 mm) or more in width (including space measured around corners) and unbroken along the floor line by doorways and similar openings, fireplaces, stationary appliances, and fixed cabinets that do not have countertops or similar work surfaces
- (2) The space occupied by fixed panels in walls, excluding sliding panels
- (3) The space afforded by fixed room dividers, such as freestanding bar-type counters or railings

(3) Receptacle outlets in or on floors shall not be counted as part of the required number of receptacle outlets unless located within 18 in. (450 mm) of the wall.

(4) Receptacles installed for countertop and similar work surfaces as specified in 210.52(C) shall not be considered as the receptacle outlets required by 210.52(A).

Examples of rooms that are not meeting rooms include auditoriums, schoolrooms, and coffee shops »*210.65(A) Informational Note No. 2*«.

See 314.27(B) for floor boxes used for receptacles located in the floor »*210.65(B)(2) Informational Note No. 1*«.

See 518.1 for assembly occupancies designed for 100 or more persons »*210.65(B)(2) Informational Note No. 2*«.

A Each meeting room of not more than 1000 ft^2 (93 m^2) in other than dwelling units shall have outlets for nonlocking-type, 125-volt, 15- or 20-ampere receptacles. The outlets shall be installed in accordance with 210.65(B) »*210.65(A)*«.

B The total number of receptacle outlets, including floor outlets and receptacle outlets in fixed furniture, shall not be less than as determined in 210.65(B)(1) and (2). »*210.65(B)*«.

C Where a room or space is provided with movable partition(s), each room size shall be determined with the partition in the position that results in the smallest size meeting room »*210.65(A)*«.

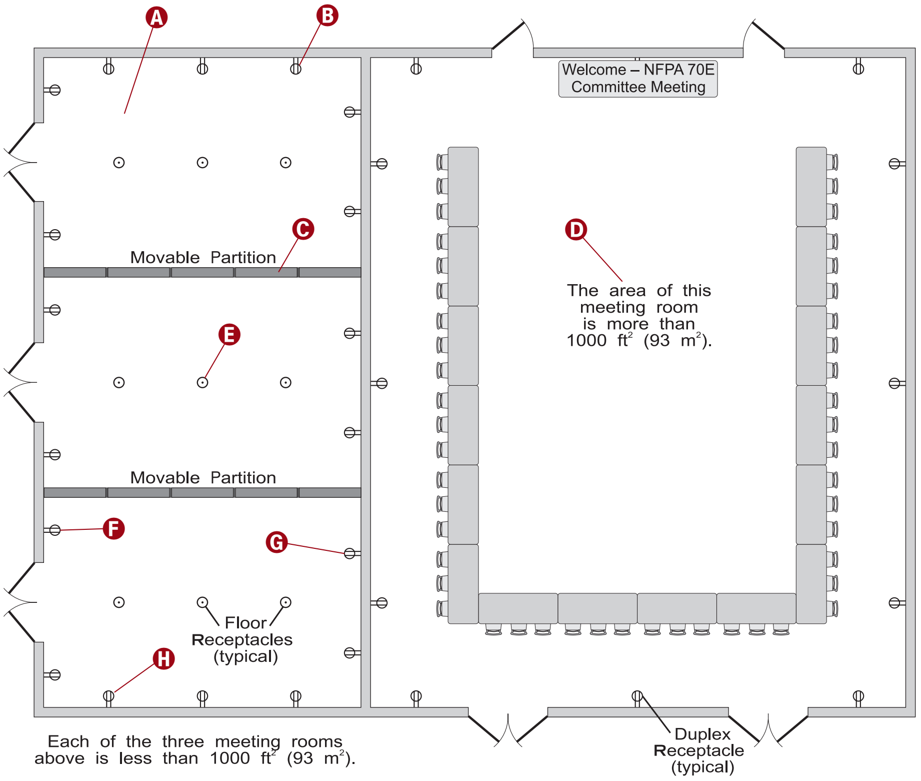
D Because the area of this meeting room is more than 1000 ft^2 (93 m^2), compliance with 210.65(B) is not required. Therefore, the receptacles in this meeting room are not required to be installed in accordance with 210.52(A)(1) through (A)(4).

E A meeting room with any floor dimension that is at least 12 ft (3.7 m) or greater in any direction and that has a floor area of at least 215 ft^2 (20 m^2) shall have at least one floor receptacle outlet, or at least one floor outlet to serve receptacle(s), located at a distance not less than 6 ft (1.8 m) from any fixed wall for each 215 ft^2 (20 m^2) or fraction of floor space »*210.65(B)(2)*«.

F Where receptacles are required in meeting rooms, the required number of receptacle outlets shall be determined in accordance with 210.52(A)(1) through (A)(4). These receptacle outlets shall be permitted to be located as determined by the installer, designer, or building owner »210.65(B)(1)«.

G Because the area of each of these three meeting room is less than 1000 ft^2 (93 m^2), compliance with 210.65(B) is required. Therefore, the receptacles shall be installed in accordance with 210.52(A)(1) through (A)(4).

H Only the quantity of receptacle outlets must comply with 210.52(A)(1) through (A)(4) and not the spacing. The receptacle outlets can be spaced as desired.


A
B
Welcome – NFPA 70E
Committee Meeting
C
Movable Partition
D
The area of this meeting room is more than 1000 ft² (93 m²).
E
Movable Partition
F
G
Floor Receptacles (typical)
H
Each of the three meeting rooms above is less than 1000 ft² (93 m²).
Duplex Receptacle (typical)

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Motion Picture (and Television) Studios and Remote Locations

Comprehensive Requirements

Portable electrical equipment, including distribution systems, generators, battery systems, and other power sources, shall be deployed, energized, and, while energized, operated and continuously supervised by trained, qualified, and employer-authorized personnel »*530.4*«.

Stage or set permanent wiring shall be Type MC cable, Type AC cable containing an insulated equipment grounding conductor sized per Table 250.122, Type MI cable, or approved raceways »*530.5(A)*«.

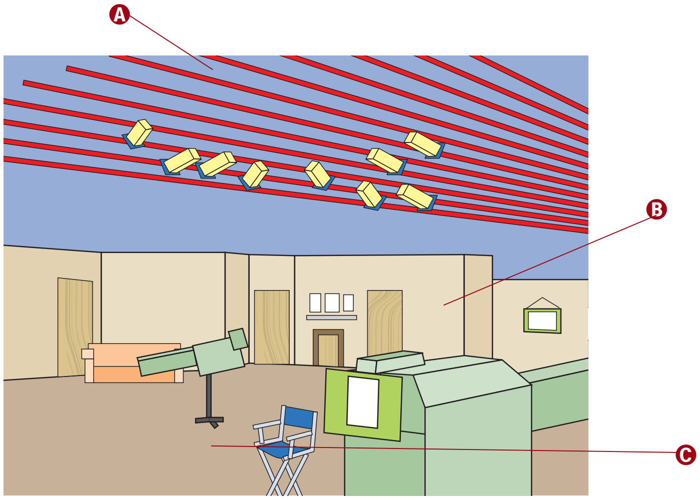
The wiring for stage set lighting and other supply wiring not fixed in place shall be achieved with listed hard usage flexible cords/cables. Where subject to physical damage, such flexible cords/cables shall be of the listed extra-hard usage type. Cable splices or taps are allowed, provided the total connected load does not exceed the cable's maximum ampacity »*530.22(A)*«.

Stage effects and electrical equipment used as stage properties can be wired with single- or multiconductor listed flexible cords or cables where protected from physical damage and secured to the scenery by approved cable ties or insulated staples. Splices (or taps) can only be made with listed devices in a circuit protected at no more than 20 amperes »*530.22(B)*«.

Switches used for studio stage set lighting and effects (on the stages and lots and on location) shall be of the externally operable type »*530.12(B)*«.

Parts of electrical equipment that are live or are likely to become energized shall be enclosed, guarded, or located so persons cannot accidentally come in contact with them or bring conductive material into contact with them »*530.12(A)*«.

Portable luminaires shall be listed »*530.26(A)*«. Portable luminaires used as properties on a motion picture or television stage set, on a studio stage or lot, or on location are, for this purpose, not considered portable luminaires »*530.26(A) Exception*«.



Overcurrent protective devices used in production areas must comply with 530.23(A) through (D).

Ⓐ Article 530 requirements apply to motion picture/television studios in facilities and locations staffed by qualified persons, except as provided in 520.1. Such occupancies shall include those using either electronic or film cameras for image capture »*530.1*«. See NFPA 40-2019, Standard for the Storage and Handling of Cellulose Nitrate Film, for methods of protecting against cellulose nitrate film hazards »*530.1 Informational Note*«.

Ⓑ **Stage set:** A specific area set up with temporary scenery and properties planned for a particular scene in a motion picture or television production scene »*Article 100*«.

Ⓒ **Motion picture studio (television studio):** A building, group of buildings, other structures, and outdoor areas designed, constructed, permanently altered, designated, or approved for the purpose of motion picture or television production »*Article 100*«.

It shall be permissible to apply Table 530.7 demand factors to that portion of the maximum possible connected load for studio or stage set lighting for all permanently installed feeders between substations and stages and to all permanently installed feeders between the main stage switchboard and stage distribution centers (or location boards) »*530.7*«.

Plugs and receptacles, including cord connectors and flanged surface devices, shall be rated in amperes. The voltage rating of plugs and receptacles shall not be less than the nominal circuit voltage. All ac circuit plug and receptacle ampere ratings shall not be less than the feeder (or branch-circuit) overcurrent device ampere rating. Table 210.21(B)(2) shall not apply »*530.9(A)*«.

Single-pole separable connectors shall comply with the requirements of 406.13. Sections 400.14, 406.7, and 406.8 shall not apply to listed single-pole separable connectors. Paralleled sets of current-carrying single-pole separable connectors acting as input devices shall carry prominent warning labels indicating the presence of internal parallel connections. All paralleled input devices shall be guarded against accidental contact »*530.10(A)* and *(B)*«.

Note

Permanent wiring systems shall include an equipment grounding conductor of a type listed in 250.118 and sized in accordance with 250.122. This does not apply to pendant and portable stage lighting, stage sound equipment, or other special stage equipment operating at not over 150 volts dc to ground »***530.8***«.

Motion Picture Projection Rooms

General Provisions

Nonprofessional projectors: Nonprofessional projectors are those types of projectors that do not comply with the definition of *Professional-Type Projector* »*Article 100*«. These projectors, including miniature types, employing cellulose acetate (safety) film may be operated without a projection room »*540.31*«.

Motor-generator sets, transformers, rectifiers, rheostats, and similar equipment for the supply (or control) of current to projection (or spotlight equipment) using nitrate film shall be located in a separate room. If inside the projection room, they shall be located (or guarded) so that arcs/sparks cannot contact film, and the commutator end(s) of motor generator sets shall comply with *one* of the following conditions:

1. **Be of the totally enclosed, enclosed fan-cooled, or enclosed pipe-ventilated type.**
2. **Be enclosed in separate rooms or housings built of noncombustible material constructed so as to exclude flyings or lint with approved ventilation from a source of clean air.**
3. **Have the motor-generator brush or sliding-contact end enclosed by solid metal covers.**
4. **Have brushes or sliding contacts enclosed in substantial, tight metal housings.**
5. **Have the upper half of the brush or sliding-contact end of the motor-generator enclosed by a wire screen (or perforated metal), and the lower half enclosed by solid metal covers.**
6. **Have wire screens or perforated metal placed at the commutator of brush ends. No dimension of any opening in the wire screen or perforated metal shall exceed 0.05 in. (1.27 mm), regardless of the shape of the opening and of the material used »*540.11(A)*«.**

Extraneous equipment (switches, overcurrent devices, etc.), not normally a part of projection, sound reproduction, flood or other special effect lamps, shall not be placed in projection rooms unless an exception is met »*540.11(B)*«.

Conductors supplying outlets for arc and xenon projectors (professional-type) shall have an ampacity not less than the projector current rating, but in no case smaller than 8 AWG. Conductors for incandescent-type projectors shall conform to the normal wiring standards of 210.24 »*540.13*«.

Insulated conductors having an operating temperature rating no less than 200°C (392°F) shall be used on all lamps (or other equipment) where the ambient temperature at the installed conductors will exceed 50°C (122°F) »*540.14*«.

Ⓐ Article 540 provisions apply to motion picture projection rooms, motion picture projectors, and associated equipment, both professional and nonprofessional types, that use incandescent, carbon arc, xenon, or other light source equipment capable of producing hazardous gases, dust, or radiation »*540.1*«.

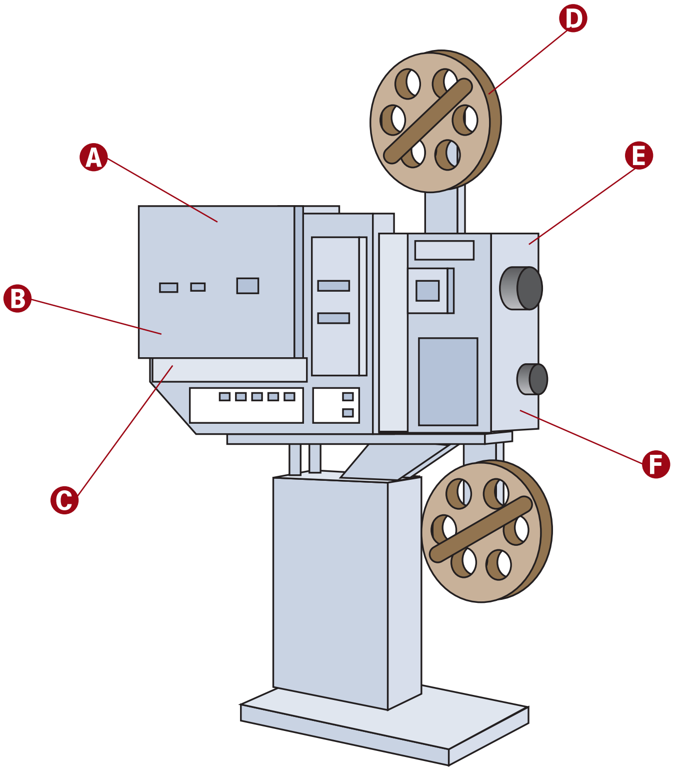
Ⓑ Every professional-type projector shall be located within a permanently constructed projection room approved for the type of building in which it is located. All projection ports, spotlight ports, viewing ports, and similar openings shall be completely enclosed by use of glass or other approved material. Such rooms do not qualify as hazardous (classified) locations as defined in article 500 »*540.10*«.

Ⓒ A minimum 30-in. (750-mm) wide working space shall be provided on each side and at the rear of each motion picture projector, floodlight, spotlight, or similar equipment »*540.12*«. Adjacent pieces of equipment can be served by one such space »*540.12 Exception*«.

Ⓓ **Professional-type projector:** Projectors using either (1) 35- or 70-mm film (a minimum of 1⅜ in. [35 mm] wide with 5.4 edge perforations per inch [212 perforations per meter]) or (2) a type using carbon arc, xenon, or other light source equipment producing hazardous gases, dust, or radiation »*Article 100*«.

Ⓔ Projectors and enclosures for arc, xenon, and incandescent lamps and rectifiers, transformers, rheostats, and similar equipment shall be listed »*540.20*«.

Ⓕ Projectors and other equipment shall be marked with the manufacturer's name (or trademark) as well as the voltage and current for which they are designed, per 110.21 »*540.21*«.



Manufactured Buildings and Relocatable Structures

Manufactured Building Requirements

Fittings and connectors to be concealed at the time of on-site assembly (where tested, identified, and listed to applicable standards) are permitted for on-site module/component interconnection. Such fittings and connectors shall equal the employed wiring method in insulation, temperature rise, and fault-current withstand. They shall also be able to endure the vibration and minor relative motions occurring in the manufactured building components »*545.13*«.

In closed construction, cables can be secured only at cabinets, boxes, or fittings where using 10 AWG or smaller conductors and protection against physical damage is provided »*545.4(B)*«.

Provisions shall be made to route the service-entrance conductors, underground service conductors, service-lateral, feeder, or branch-circuit supply to the service or building disconnecting means conductors »*545.5*«.

Install service-entrance conductors after the building is site-erected, unless the point of attachment location is known prior to manufacture »*545.6*«.

Exposed conductors and equipment shall be protected during manufacturing, packaging, transit, and setup at the building site »*545.8*«.

Boxes of dimensions other than those required in Table 314.16(A) can be installed where tested, identified, and listed to applicable standards »*545.9(A)*«.

Any box no larger than 100 in.^{3} (1650 cm^3) and intended for closed-construction mounting shall be affixed with anchors (or clamps) to provide a rigid and secure installation »*545.9(B)*«.

A receptacle (or switch) with integral enclosure and mounting means can be installed where such is tested, identified, and listed to applicable standards »*545.10*«.

Prewired panels and building components shall provide for the bonding, or bonding and grounding, of all exposed metals likely to be energized, per Article 250, Parts V, VI, and VII »*545.11*«.

Provisions shall be made to route a grounding electrode conductor from the service, feeder, or branch-circuit supply to the point of attachment to the grounding electrode »*545.12*«.

Closed construction: Any building, building component, assembly, or system manufactured in such a manner that concealed parts of manufacture processes cannot be inspected after building site installation without disassembly, damage, or destruction »*Article 100*«.

Building component: Any subsystem, subassembly, or other system designed for use in, integral with, or as part of a structure. A building component can be structural, electrical, mechanical, plumbing, fire protection, and other health and safety systems »*Article 100*«.

Building system: Plans, specifications, and documentation for a manufactured building system, or for a type of system building component, such as structural, electrical, mechanical, plumbing, fire protection, and other systems affecting health and safety, including variations thereof specifically permitted by regulation, provided the variations are submitted as part of the building system or as an amendment thereto »*Article 100*«.

Ⓐ Article 545 covers requirements for manufactured buildings, building components, relocatable structures, and the conductors that connect relocatable structures to a supply of electricity »*545.1*«.

Ⓑ **Manufactured building:** Any closed construction building made (or assembled) in manufacturing facilities, whether on or off the building site, for installation, or assembly and installation, on the building site, excluding manufactured homes, mobile homes, park trailers, or recreational vehicles »*Article 100*«.

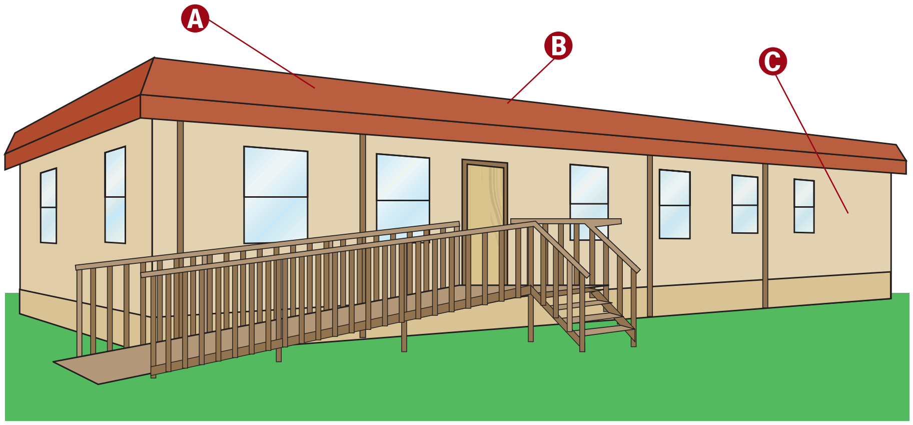
Ⓒ All raceways and cable wiring methods included in the *NEC* and other wiring systems specifically intended and listed for use in manufactured buildings shall be permitted with listed fittings and with fittings listed and identified for manufactured buildings »*545.4(A)*«.

Note

Service equipment shall be installed in accordance with 230.70 »***545.7***«.

Note

Part II of Article 545 contains requirements for relocatable structures.



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Agricultural Buildings

Agricultural Building Provisions

Motors and other rotating electrical machinery shall either be totally enclosed or designed to minimize the entrance of dust, moisture, or corrosive particles »*547.30*«.

Equipotential planes shall be bonded to the grounding electrode system or an equipment grounding terminal in any panelboard of the electrical grounding system associated with the equipotential plane. The bonding conductor shall be solid copper, insulated, covered or bare, and not smaller than 8 AWG. The means of bonding to wire mesh or conductive elements shall be by pressure connectors or clamps of brass, copper, copper alloy, or other approved means. Slatted floors that are supported by structures that are a part of an equipotential plane shall not require bonding »*547.44(B)*«.

For the purpose of 547.44, the term *livestock* does not include poultry »*547.44*«.

A This article's provisions apply to agricultural buildings, part of buildings, or adjacent areas of similar nature as specified in (A) or (B).

(A) Agricultural buildings where excessive dust, and dust in combination with water, may accumulate. Included are all areas of poultry, livestock, and fish confinement systems, where litter dust or feed dust (including mineral feed particles) may accumulate.

(B) Agricultural buildings with a corrosive atmosphere. Such buildings include areas where:

(1) poultry and animal excrement can cause corrosive vapors,

(2) corrosive particles may mix with water,

(3) periodic washing for cleaning and sanitizing with water and cleansing agents creates a damp, even wet, environment,

(4) similar conditions exist »*547.1*«.

B The wiring method(s) employed shall be types UF, NMC, copper SE cables, jacketed Type MC cable, or raceways identified for the locations specified in 547.1(A) and (B). Wiring methods specified in Part II of Article 502 are permitted for areas described in 547.1(A) »*547.20*«.

C Conductive elements that are connected together to minimize voltage differences are defined as an equipotential plane »*Article 100*«.

D All cables shall be secured within 8 in. (200 mm) of each cabinet, box, or fitting. Nonmetallic boxes, fittings, conduit, and cables shall be permitted to be mounted directly to any building surface covered by this article without maintaining the ¼-in. (6-mm) airspace in accordance with 300.6(D) »*547.21*«.

Caution

Protect all electrical wiring and equipment subject to physical damage »*547.26*«.

E Luminaires shall comply with all of the following:

A. By installation, the entrance and accumulation of dust, foreign matter, moisture, and corrosive material shall be minimized.

B. If subject to physical damage, shall have a suitably protective guard.

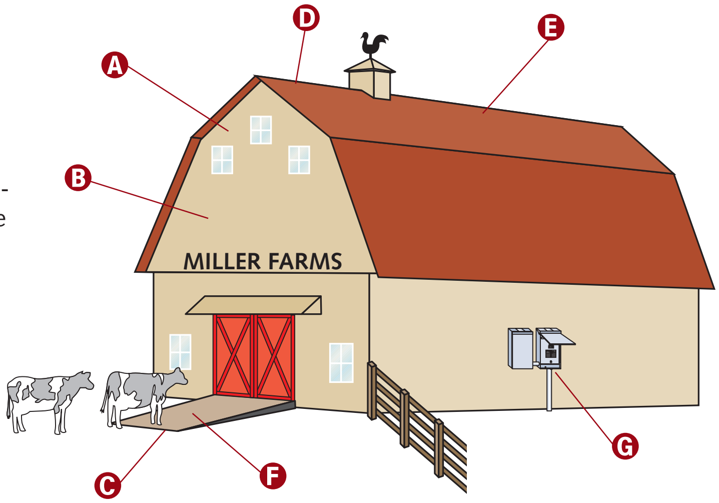
C. If exposed to water, whether from condensation, building cleansing water, or solution, shall be listed for use in wet locations »*547.31*«.

F **Indoors:** Equipotential planes shall be installed in confinement areas with concrete floors where metallic equipment is located that may become energized and is accessible to livestock »*547.44(A)(1)*«. **Outdoors:** Equipotential planes shall be installed in concrete slabs where metallic equipment is located that may become energized and is accessible to livestock. The equipotential plane shall encompass the area where the livestock stands while accessing metallic equipment that may become energized »*547.44(A)(2)*«.

G Where a separate equipment grounding conductor, not part of a listed cable assembly, is installed underground within a location falling under the scope of 547.1, it shall be insulated »*547.27*«. For further information on aluminum and copper-clad aluminum conductors, see 250.120(B) »*547.27 Informational Note*«.

Note

GFCI protection shall be provided as required in 210.8(B). GFCI protection shall not be required for other than 125-volt, 15- and 20-ampere receptacles installed within (1) areas requiring an equipotential plane; (2) outdoors; (3) damp or wet locations; or (4) dirt confinement areas for livestock »***547.28***«.



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Mobile Homes, Manufactured Homes, and Mobile Home Parks

General Requirements

Mobile home: A factory-assembled structure transportable in one or more sections, built on a permanent chassis, designed for use as a dwelling having no permanent foundation where connected to the required utilities, and including the plumbing, heating, air-conditioning, and electric systems contained therein »*Article 100*«.

Manufactured home: A structure, transportable in one or more sections, which in traveling mode, is 8 ft (2.4 m) or more in width, or 40 ft (12.2 m) or more in length, or, when erected on site, is 320 ft^2 (29.77 m^2) or more, built on a permanent chassis, and is designed for dwelling use (with or without a permanent foundation) whether or not connected to the utilities, and includes plumbing, heating, air conditioning, and electrical systems contained therein »*Article 100*«.

At least one receptacle outlet shall be installed outdoors accessible at grade level, and not more than 6½ ft (2.0 m) above grade. A receptacle outlet located in an outside accessible compartment qualifies as an outdoor receptacle. These receptacle outlets shall have GFCI protection for personnel »*210.8(A)(3) and 550.13(B) and (D)(8)*«.

A receptacle outlet must be installed on the underside of the unit for the connection of pipe heating cable(s) and shall be:

1. Located within 2 ft (600 mm) of the cold water inlet.
2. Connected to an interior branch circuit, other than a small-appliance branch circuit. A bathroom receptacle circuit can be utilized for this purpose.
3. On a circuit where all outlets are on the load side of the ground-fault circuit-interrupter protection for personnel.
4. This outlet is not considered to be the outdoor receptacle outlet required in 550.13 (D)(8) »*550.13(E)*«.

Use only approved and listed fixed-type wiring methods to join portions of a circuit that must be electrically joined and are located in adjacent mobile home sections after installation on its support foundation. The circuit's junction shall be accessible for disassembly when preparing the home for relocation »*550.19(A)*«.

Note

Mobile homes not installed in mobile home parks shall comply with the provisions of this article »*550.4(A)*«.

GFCI protection shall be provided as required in 210.8(A). In addition, in the following areas within a mobile or manufactured home, GFCI protection is limited to 125-volt, 15- and 20-ampere receptacles or outlets in the following locations: (1) compartments accessible from outside the unit; (2) bathrooms, including receptacles in luminaires; (3) kitchens, where receptacles are installed to serve countertop surfaces; (4) sinks, where receptacles are installed within 6 ft (1.8 m) of the outer edge of the sink (5) dishwashers »*550.13(B)*«.

A Article 550 provisions cover the electrical conductors and equipment in or on mobile and manufactured homes, mobile and manufactured home electrical supply conductors, and the installation of electrical wiring, luminaires, equipment, and appurtenances related to electrical installations within a mobile home park up to the mobile home service-entrance conductors or, if none, the service equipment »*550.1*«.

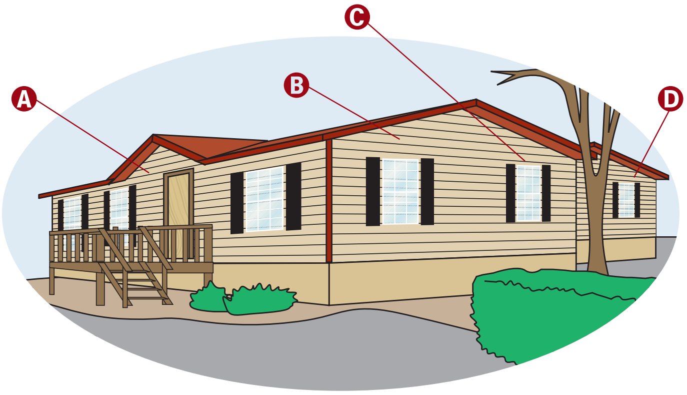
B For *Code* purposes (unless otherwise indicated), the term ***mobile home*** includes manufactured homes and excludes park trailers »*Article 100 Informational Note under the definition of Mobile Home*«.

C This article's provisions apply to mobile homes designed to connect to a wiring system rated 120/240 volts, nominal, 3-wire ac, with grounded neutral conductor »*550.4(B)*«.

D Outdoor or under-chassis line-voltage (120 volts, nominal, or higher) wiring exposed shall be protected by a conduit or raceway identified for use in wet locations. The conductors shall be listed for use in wet locations »*550.15(H)(1)*«.

Caution

All electrical materials, devices, appliances, fittings, and other equipment shall be listed and labeled by a qualified testing agency and connected in an approved manner when installed »*550.4(C)*«.



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Power Supply

Cords with adapters and pigtail ends, extension cords, and similar items shall not be attached to or shipped with a mobile home »*550.10(B)*«.

A cord passing through walls or floors shall be protected by means of conduits and bushings (or equivalent). The cord can be installed within the walls, provided a continuous raceway (maximum 1¼ in. [32 mm] in size) is installed from the branch-circuit panelboard to the underside of the mobile home floor »*550.10(G)*«.

The power-supply cord's attachment plug cap and any connector cord assembly or receptacle shall be permanently protected against corrosion and mechanical damage, if such devices are externally located while the mobile home is in transit »*550.10(H)*«.

If the calculated load exceeds 50 amperes, or if a permanent feeder is used, the supply shall be by one of the following means:

1. **One mast weatherhead installation, installed per Part II of Article 230, containing four continuous, insulated, color-coded feeder conductors, one of which shall be an equipment grounding conductor.**
2. **An RMC, IMC, PVC, or other raceway identified for the location from the internal disconnecting means to the mobile home's underside, with provisions for attachment to the raceway on the mobile home's underside via a suitable junction box (or fitting) (with or without conductors as in 550.10[I][1]) »*550.10(I)*«.**

A The attachment plug cap shall not only be a 3-pole, 4-wire, grounding type, rated 50 amperes, 125/250 volts with a configuration as shown in Figure 550.10(C) but also shall be intended for use with a 50-ampere, 125/250-volt receptacle configuration as shown in Figure 550.10(C). It shall be listed, individually or as part of a power-supply cord assembly, for such purpose, and molded to (or installed on) the flexible cord at the point where the cord enters the attachment plug cap »*550.10(C)*«.

B In a right-angle cap configuration, the grounding member shall be the farthest from the cord »*550.10(C)*«.

C The mobile home power supply shall be a feeder assembly consisting of a single listed 50-ampere mobile home power-supply cord or a permanently installed feeder »*550.10(A)*«.

D The power-supply cord shall bear the marking: "FOR USE WITH MOBILE HOMES—40 AMPERES" or "FOR USE WITH MOBILE HOMES—50 AMPERES" »*550.10(E)*«.

E The cord shall be a four-conductor listed type. One conductor shall be identified by a continuous green color, or a continuous green color with one or more yellow stripes, for use as the equipment grounding conductor »*550.10(B)*«.

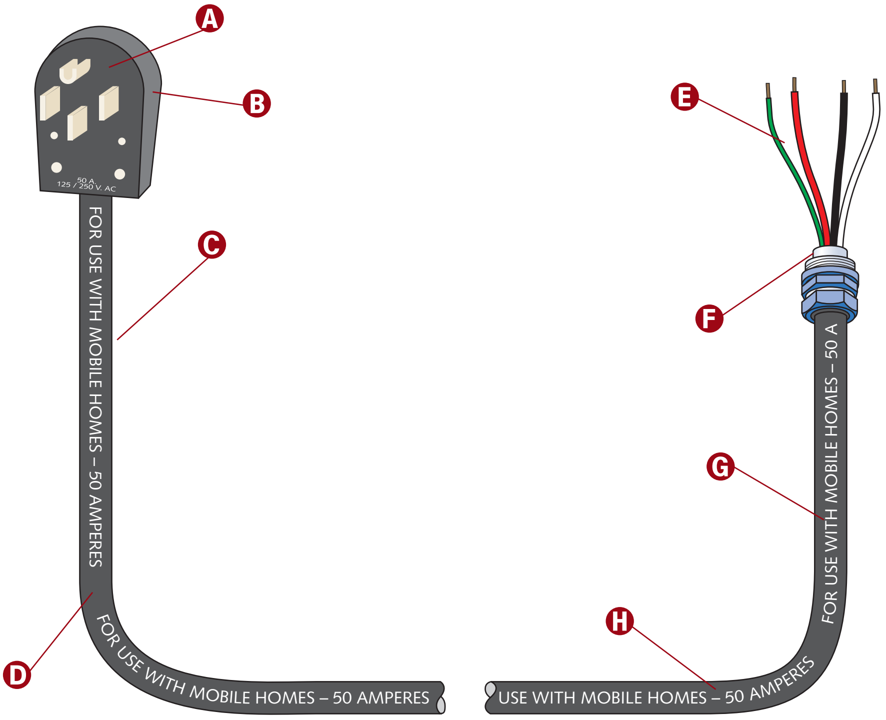
F A suitable clamp (or equivalent) shall be provided at the panelboard knockout to afford cord strain relief and effectively prevent strain transmission to the terminals when the power-supply cord is handled as intended »*550.10(B)*«.

G A mobile home power-supply cord, if present, shall be permanently attached to the panelboard either directly or via a junction box also permanently connected thereto, with the free end terminating in an attachment plug cap »*550.10(B)*«.

H From the end of the power-supply cord (including bared leads) to the face of the attachment plug cap, the cord shall not be less than 21 ft (6.4 m) or more than 36½ ft (11 m) in length. From the face of the attachment plug cap to the mobile home entry point, the cord shall be at least 20 ft (6.0 m) long »*550.10(D)*«.

Note

The feeder assembly shall enter the mobile home through an exterior wall, the floor, or roof »*550.10(F)*«.


A
B
50 A
125 / 250 V. AC
C
FOR USE WITH MOBILE HOMES – 50 AMPERES
D
FOR USE WITH MOBILE HOMES – 50 AMPERES
E
F
FOR USE WITH MOBILE HOMES – 50 A
G
H
USE WITH MOBILE HOMES – 50 AMPERES

Panelboards and Branch Circuits

A panelboard shall be rated no less than 50 amperes and employ a 2-pole circuit breaker rated 40 amperes for a 40-ampere supply cord, or 50 amperes for a 50-ampere supply cord. A panelboard employing a disconnect switch and fuses shall be rated 60 amperes and employ a single two-pole, 60-ampere fuseholder with 40- or 50-ampere main fuses for 40- or 50-ampere supply cords, respectively. The fuse size shall be plainly marked on the outside of the panelboard »*550.11(A)*«.

Each mobile home shall have branch-circuit distribution equipment that includes circuit breaker or fuse overcurrent protection for each branch circuit. The branch-circuit overcurrent devices shall be rated as follows: (1) not more than the circuit conductors and (2) not more than 150% of a single appliance rated 13.3 amperes (or more) supplied by an individual branch circuit, but (3) not more than the overcurrent protection size and type marked on the air conditioner (or other motor-operated appliance) »*550.11(B)*«.

A metal nameplate on the outside adjacent to the feeder assembly entrance shall read:

THIS CONNECTION FOR 120/240-VOLT, 3-POLE, 4-WIRE, 60-HERTZ, _____-AMPERE SUPPLY

Fill in the blank with the correct ampere rating »*550.11(D)*«.

Multiply 3 volt-amperes/ft^2 (33 volt-amperes/m^2) by the outside dimensions of the mobile home (coupler excluded) and divide by 120 volts to determine the number of 15- or 20-ampere lighting circuits »*550.12(A)*«.

There shall be one or more adequately rated circuits in accordance with the following:

1. **Ampere rating of fixed appliances not over 50% of circuit rating if lighting outlets (receptacles, other than kitchen, dining area, and laundry, considered as lighting outlets) exist on the same circuit.**
2. **For fixed appliances on a circuit without lighting outlets, the sum of rated amperes shall not exceed the branch-circuit rating. Motor loads or continuous loads shall not exceed 80% of the branch-circuit rating.**
3. **The rating of a single cord- and plug-connected appliance on a circuit having no other outlets shall not exceed 80% of the circuit rating.**
4. **The rating of a range branch circuit shall be based on the range demand as specified in 550.18(B)(5) »*550.12(D)*«.**

Ⓐ Each mobile home shall have a single disconnecting means consisting of a circuit breaker, or a switch and fuses, and its accessories installed in a readily accessible location near the supply cord (or conductor's) entry point into the mobile home. The main circuit breakers (or fuses) shall be plainly marked "Main." This equipment shall contain a solderless-type grounding connector (or bar) with sufficient terminals for all grounding conductors. The terminations of the grounded circuit conductors shall be insulated in accordance with 550.16(A) »*550.11(A)*«.

Ⓑ While the panelboard shall be located in an accessible location, it shall not be located in a bathroom or clothes closet. A clear working space at least 30 in. (750 mm) wide and 30 in. (750 mm) in front of the panelboard shall be provided. This space shall extend from the floor to the top of the panelboard »*550.11(A)*«.

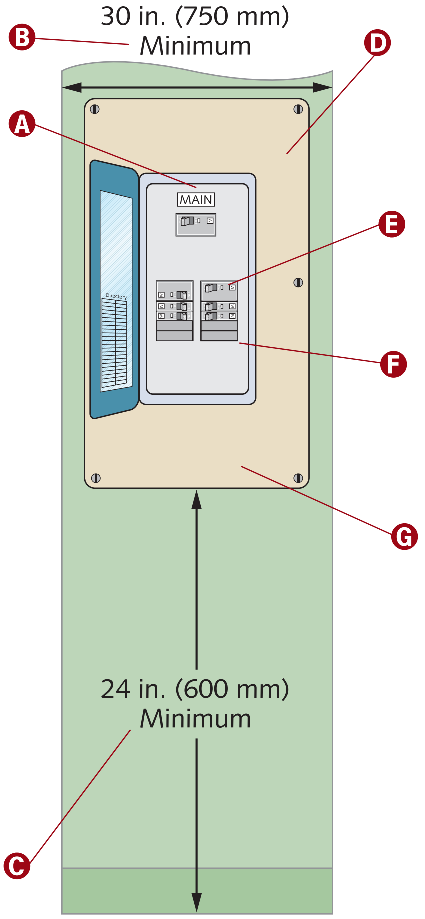
Ⓒ The bottom of the distribution equipment, whether circuit breaker or fused type, shall be at least 24 in. (600 mm) above the mobile home's floor level »*550.11(A)*«.

Ⓓ The distribution equipment shall have a rating not less than the calculated load »*550.11(A)*«.

Ⓔ Where circuit breakers provide branch-circuit protection, 240-volt circuits shall be protected by a 2-pole common or companion trip, or circuit breakers with identified handle ties »*550.11(C)*«.

Ⓕ Determine the required number of branch circuits in accordance with 550.12(A) through (E) »*550.12*«.

Ⓖ The branch-circuit equipment can be combined with the disconnecting means as a single assembly. Such a combination can be designated as a panelboard. If a fused panelboard is used, the maximum fuse size for the mains shall be plainly marked with ¼-in. (6-mm) or taller lettering visible during fuse replacements. If plug fuses and fuseholders are used, they shall be tamper-resistant Type S, enclosed in dead-front fuse panelboards. Electrical panelboards containing circuit breakers shall also be dead-front type »*550.11*«.



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Grounding

Cord-connected appliances (such as washing machines, clothes dryers, refrigerators, and the electrical system of gas ranges) shall be grounded via a cord having an equipment grounding conductor and grounding-type attachment plug »*550.16(B)(3)*«.

Metallic pipes (gas, water, and waste) as well as metallic air-circulating ducts are considered bonded if connected to the chassis terminal by clamps, solderless connectors, or appropriate grounding-type straps »*550.16(C)(3)*«.

Any metallic exterior covering is considered bonded if (1) the metal panels overlap one another and are securely attached to the wood or metal frame parts by metallic fasteners and (2) the lower panel of the metallic exterior covering is secured at opposite ends by metallic fasteners at a chassis cross member by two metal straps on opposite ends per mobile home unit (or section). The bonding strap shall be at least 4 in. (100 mm) wide and of the same material as the skin, or of a material of equal or better electrical conductivity. The straps shall be fastened with paint-penetrating fittings such as screws and starwashers or equivalent »*550.16(C)(4)*«.

In the electrical system, all exposed metal parts, enclosures, frames, luminaire canopies, etc. shall be effectively bonded to the grounding terminal or enclosure of the panelboard »*550.16(B)(2)*«.

Ⓐ Grounding terminals shall be of the solderless type, listed as pressure-terminal connectors, and recognized for the wire size employed »*550.16(C)(2)*«.

Ⓑ The supply cord or permanent feeder's green-colored insulated grounding wire shall be connected to the grounding bus in the panelboard or disconnecting means »*550.16(B)(1)*«.

Note

Connections of ranges and clothes dryers with 120/240-volt, 3-wire ratings shall be made with 4-conductor cord and 3-pole, 4-wire, grounding-type plugs or by Type AC cable, Type MC cable, or conductors enclosed in flexible metal conduit »*550.16(A)(2)*«.

Caution

Neither the mobile home's frame nor any appliance frame shall be connected to the grounded circuit conductor (neutral) in the mobile home »*550.16*«.

Note

Chassis of multiple mobile home sections shall be bonded together with a solid copper, 8 AWG minimum, insulated or bare, bonding conductor with terminations in accordance with 250.8 and 250.12 »*550.16(C)(1)*«.

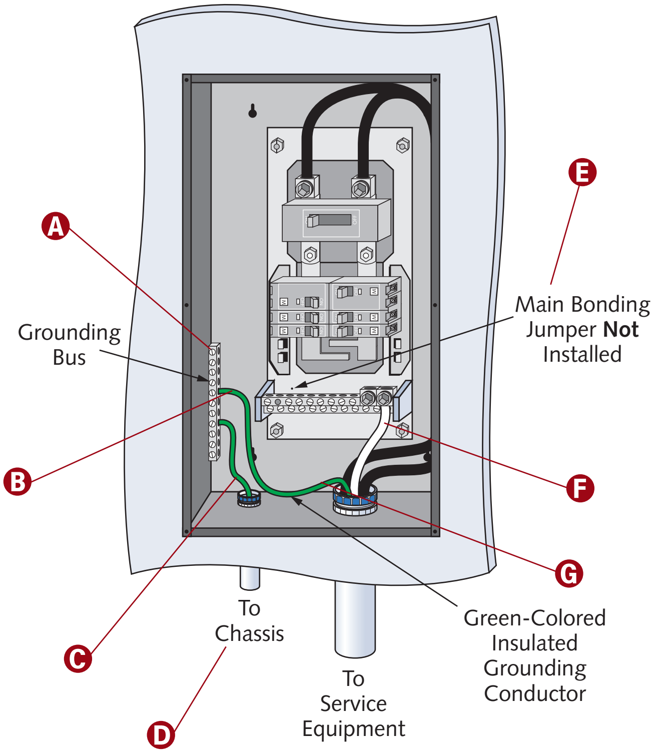
Ⓒ The bonding conductor shall be solid or stranded, insulated or bare, but shall be 8 AWG copper minimum, or the equivalent. The bonding conductor routing shall prevent physical damage exposure »*550.16(C)(2)*«.

Ⓓ All potentially energizable exposed, non-current-carrying metal parts shall be effectively bonded to either the grounding terminal or the panelboard's enclosure. A bonding conductor shall be connected between the panelboard and an accessible terminal on the chassis »*550.16(C)(1)*«.

Ⓔ Remove and discard bonding screws, straps, or buses in the panelboard or in appliances »*550.16(A)(1)*«.

Ⓕ The grounded circuit conductor (neutral) shall be insulated from the equipment grounding conductors, from equipment enclosures, and other grounded parts. The grounded circuit terminals in panelboards, ranges, clothes dryers, counter-mounted cooking units, and wall-mounted ovens shall be insulated from the equipment enclosure »*550.16(A)(1)*«.

Ⓖ In a mobile home, grounding of metal parts (both electrical and nonelectrical) shall be accomplished by connection to a panelboard's grounding bus and shall be connected through the green-colored insulated conductor in the supply cord (or the feeder wiring) to the grounding bus in the service-entrance equipment, located adjacent to the mobile home »*550.16*«.


E
A
Main Bonding Jumper Not Installed
Grounding Bus
B
F
G
C
To Chassis
To Service Equipment
Green-Colored Insulated Grounding Conductor
D

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Services and Feeders

The mobile home park secondary electrical distribution system supplying mobile home lots shall be single-phase, 120/240 volts, nominal »*550.30*«.

The manufactured home service equipment can be installed in or on a manufactured home, provided all of the conditions in 550.32(B) are met »*550.32(B)*«.

Park electrical wiring systems shall be calculated (at 120/240 volts) on the larger of (1) 16,000 volt-amperes for each mobile home lot or (2) the load calculated per 550.18 for the largest typical mobile home that each lot accepts. The feeder or service load can be calculated in accordance with Table 550.31. No demand factor is allowed for any other load, except as provided in this *Code* »*550.31*«.

Feeder conductors shall consist of either (1) a listed cord, factory installed in accordance with 550.10(B), or a permanently installed feeder consisting of four insulated, color-coded conductors that shall be identified by the factory or field marking of the conductors in compliance with 310.6. Equipment grounding conductors shall not be identified by stripping the insulation or (2) feeder conductors shall be installed in compliance with 250.32(B) »*550.33(B)*«.

For an existing feeder that is installed without an equipment grounding conductor the installation shall be permitted to comply with 250.32(B)(1) Exception No. 1 »*550.33(B) Exception*«.

Ⓐ Mobile home service equipment shall be rated no less than 100 amperes at 120/240 volts. Provisions shall be made for connecting a mobile home feeder assembly by a permanent wiring method. Power outlets used as mobile home service equipment can also contain receptacles rated up to 50 amperes with appropriate overcurrent protection. Fifty-ampere receptacles shall conform to Figure 550.10(C)'s configuration »*550.32(C)*«.

Ⓑ Receptacles located outside a mobile or manufactured home shall be provided with GFCI protection as specified in 210.8(A). Where receptacles provide power to a mobile or manufactured home in accordance with 550.10, GFCI protection shall not be required »*550.32(E)*«.

Ⓒ Any mobile home service equipment utilizing a 125/250-volt receptacle shall be marked as follows:

TURN DISCONNECTING SWITCH
OR CIRCUIT BREAKER OFF BEFORE INSERTING
OR REMOVING PLUG. PLUG MUST
BE FULLY INSERTED OR REMOVED.

The marking shall be located adjacent to the service equipment's receptacle outlet »*550.32(G)*«.

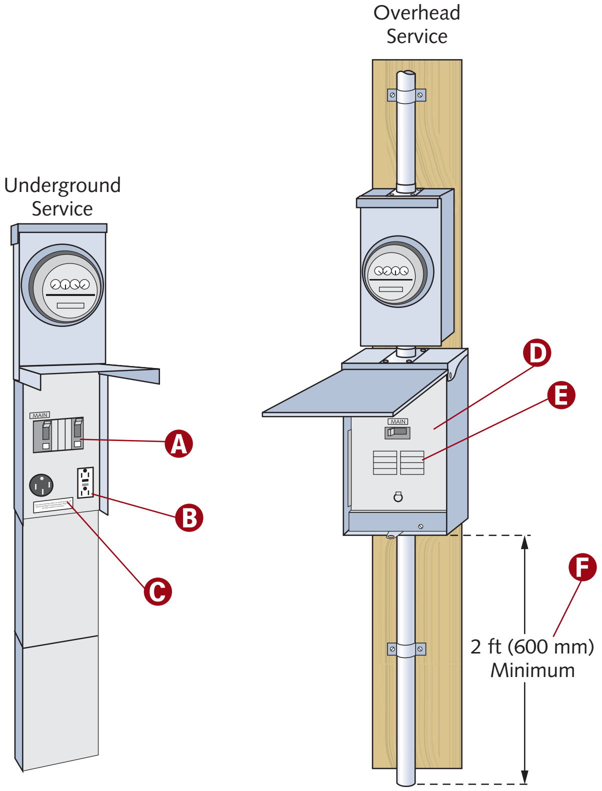
Ⓓ The mobile home service equipment shall be located adjacent to, not mounted in or on, the mobile home. It shall be located in a readily accessible location within sight from the mobile home it serves. The mobile home service disconnect shall be permitted to be used as the emergency disconnect required in 230.85 »*550.32(A)*«.

Ⓔ Mobile home service equipment or the local external disconnecting means permitted in 550.32(A) shall provide a means for connecting (by a fixed wiring method) an accessory building, structure, or additional electrical equipment located outside the mobile home »*550.32(D)*«.

Ⓕ Outdoor mobile home disconnecting means shall be installed so that the bottom of the disconnecting means enclosure is at least 2 ft (600 mm) above finished grade (or working platform). Installation shall ensure that the center of the operating handle's grip, in the highest position, is no more than 6 ft 7 in. (2.0 m) above the finished grade (or working platform) »*550.32(F)*«.

Caution

Mobile home and manufactured home feeder circuit conductors shall: (1) have a capacity not less than the loads supplied, (2) be rated at not less than 100 amperes, and (3) be permitted to be sized in accordance with 310.12 »*550.33(C)*«.



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Recreational Vehicles and Recreational Vehicle Parks

Recreational Vehicles

Recreational vehicle park: Any parcel or tract of land under the control of any person, organization, or governmental entity wherein two or more recreational vehicle, recreational park trailer, and/or other camping sites are offered for use by the public or members of an organization for overnight stays »*Article 100*«.

Recreational vehicle site: A specific area within a recreational vehicle park or campground that is set aside for use by a camping unit. »*Article 100*«.

Recreational vehicle stand: The area of a recreational vehicle site intended for the placement of a recreational vehicle »*Article 100*«.

Generator installations must comply with 551.30(A) through (E).

Recreational vehicle feeder assemblies must meet 551.44(A) through (D) requirements.

Recreational vehicle panelboard provisions are found in 551.45(A) through (C).

The feeder assembly (or assemblies) shall be factory supplied/installed and be of a type specified in 551.46(A)(1) or (2) »*551.46(A)*«.

Recreational vehicle feeder attachment plugs must meet 551.46(C) requirements.

Recreational vehicle wiring methods must comply with 551.47(A) through (S).

Ⓐ Article 551 provisions cover the electrical conductors and equipment other than low-voltage and automotive vehicle circuits or extensions thereof, installed within (or on) recreational vehicles, the conductors that connect recreational vehicles to an electrical supply, and the installation of electrical-related equipment and devices within a recreational vehicle park »*551.1*«.

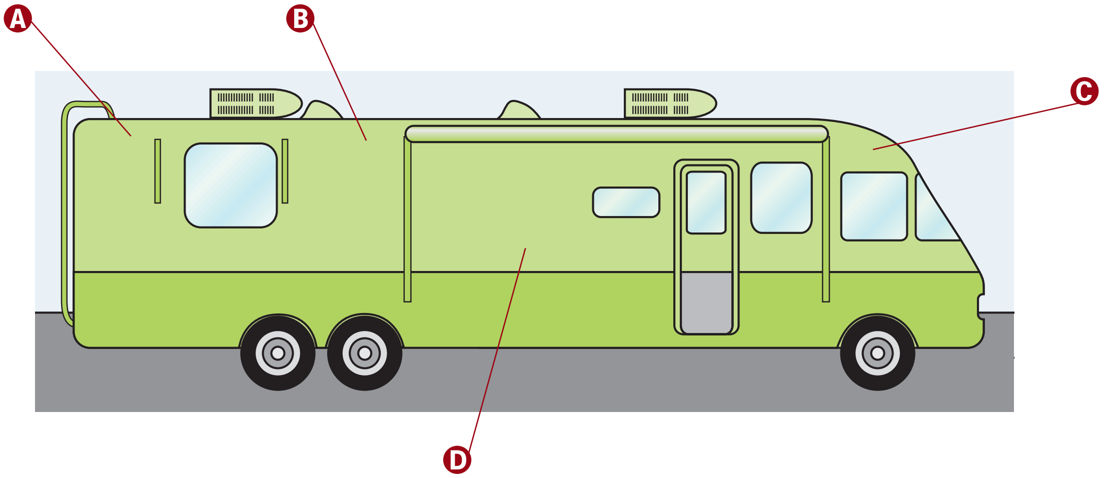
Ⓑ Recreational vehicle electrical equipment and material, intended for connection to a wiring system rated 120 volts, nominal, 2-wire with ground, or a wiring system rated 120/240 volts, nominal, 3-wire with an equipment grounding conductor, shall be listed and installed in accordance with the requirements of Parts I, II, III, IV, and V of Article 551. Electrical equipment connected line-to-line shall have a nominal voltage rating of 208–230 volts »*551.40(A)*«.

Ⓒ **Recreational vehicle (RV), (camping trailer), (motor home), (travel trailer), (truck camper):** A vehicle or slide-in camper that is primarily designed as temporary living quarters for recreational, camping, or seasonal use; has its own motive power or is mounted on or towed by another vehicle; is regulated by the National Highway Traffic Standard Administration as a vehicle or vehicle equipment; does not require a special highway use permit for operation on the highways; and can be easily transported and set up on a daily basis by an individual »*Article 100*«.

Ⓓ Every appliance shall be accessible for inspection, service, repair, and replacement without removal of permanent construction. Means shall be provided to securely fasten appliances in place during travel »*551.57*«.

Note

A recreational vehicle not used for the purpose defined in Article 100 is not required to comply with Part IV provisions relating to the number (or capacity) of circuits. The recreational vehicle shall, however, meet all other applicable requirements of this article if it has an electrical installation that can be energized from a 120-volt, a 208Y/120-volt, or 120/240-volt, nominal, ac power-supply system »***551.4(A)***«.



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Recreational Vehicle Parks

Distribution systems shall provide the voltage and have a capacity for the receptacles provided in accordance with RV site supply equipment as calculated according to 551.73 and shall have an ampacity not less than 30 amperes. Systems permitted include 120 volts, 1-phase; 120/240 volts, 1-phase; and 120/208 volts, 1-phase »*551.72(A)*«.

No grounding electrode connection can be made to the grounded conductor on the load side of the service disconnecting means except as covered in 250.30(A) for separately derived systems and 250.32(B) Exception No. 1 for separate buildings »*551.76(E)*«.

Where provided on back-in sites, the recreational vehicle site electrical equipment shall be located on the parked vehicle's left (road) side, on a line that is 5 to 7 ft (1.5 to 2.1 m) from the left edge (driver's side of the parked RV) and from 15 ft (4.5 m) forward of the rear of the stand »*551.77(A)*«.

A disconnecting switch (or circuit breaker) shall be provided in the site supply equipment for disconnecting the recreational vehicle power supply »*551.77(B)*«.

All site supply equipment shall be accessible by an unobstructed entrance or passageway at least 2 ft (600 mm) wide and 6½ ft (2.0 m) high »*551.77(C)*«.

Sufficient space shall be constantly available around all electrical equipment for ready and safe operation, in accordance with 110.26 »*551.77(E)*«.

A At least 70% of all electrically supplied recreational vehicle sites shall be equipped with a 30-ampere, 125-volt weather-resistant receptacle conforming to Figure 551.46(C)(1). Additional receptacle configurations conforming to 551.81 can be included in this supply »*551.71(B)*«. Dedicated tent sites with a 15- or 20-ampere electrical supply shall be permitted to be excluded when determining the percentage of recreational vehicle sites with 30- or 50-ampere receptacles »*551.71(D)*«.

B The recreational vehicle park secondary electrical distribution system to 50-ampere recreational vehicle sites shall be supplied from a circuit of the voltage class and rating of the receptacle. Other recreational vehicle sites with 125-volt, 20- and 30-ampere receptacles can be derived from any grounded distribution system supplying 120-volt, single-phase power. The neutral conductors shall not be reduced in size below the size of the ungrounded conductors for the site distribution. The neutral conductors can be reduced in size below the minimum required ungrounded conductor size for 240-volt, line-to-line, permanently connected loads only »*551.72(C) and (D)*«.

C Every recreational vehicle site with electrical supply shall be equipped with recreational vehicle site supply equipment with at least one 20-ampere, 125-volt weather-resistant receptacle »*551.71(A)*«.

D A minimum of 20% of existing and 40% of all new recreational vehicle sites, with electrical supply, shall each be equipped with a 50-ampere, 125/250-volt weather-resistant receptacle conforming to the configuration as identified in Figure 551.46(C)(1). Every recreational vehicle site equipped with a 50-ampere receptacle shall also be equipped with a 30-ampere, 125-volt receptacle conforming to Figure 551.46(C)(1). These electrical supplies shall be permitted to include additional receptacles that have configurations in accordance with 551.81 »*551.71(C)*«.

E Where the site supply equipment contains a 125/250-volt receptacle, the equipment shall be marked as follows: "Turn disconnecting switch or circuit breaker off before inserting or removing plug. Plug must be fully inserted or removed." The marking shall be located on the equipment adjacent to the receptacle outlet »*551.77(F)*«.

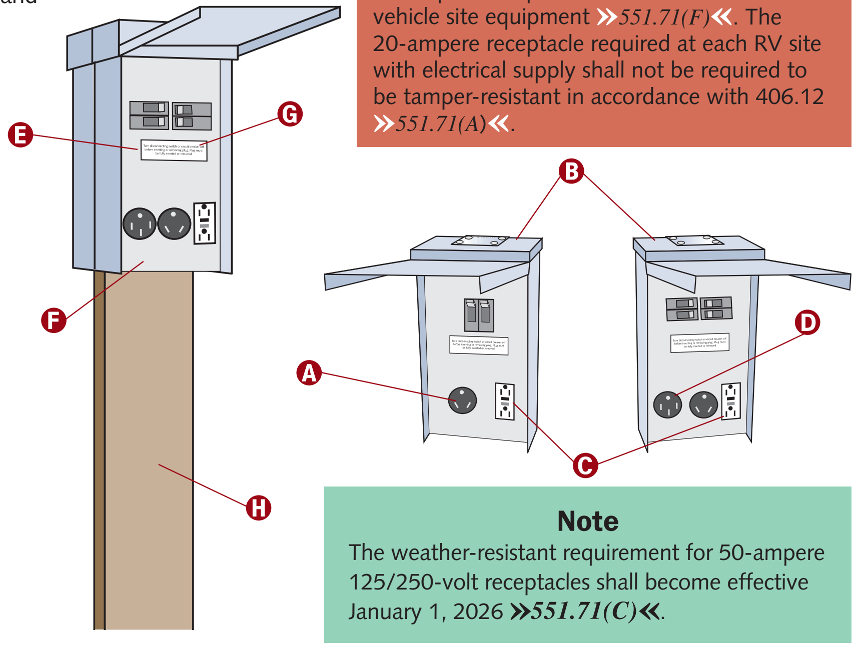
F Electrical service and feeders shall be calculated on the basis of no less than 12,000 volt-amperes per site equipped with 50-ampere, 208Y/120-volt, or 120/240-volt supply facilities; 3600 volt-amperes per site equipped with both 20-ampere and 30-ampere supply facilities; 2400 volt-amperes per site equipped with only 20-ampere supply facilities; and 600 volt-amperes per dedicated tent site with only 20-ampere supply facilities. Table 551.73(A) demand factors are the minimum allowable demand factors that can be used in calculating load for service and feeders. If the recreational vehicle site's electrical supply has more than one receptacle, the calculated load is computed for the highest rated receptacle only »*551.73(A)*«.

G Site supply equipment shall be located no less than 2 ft (600 mm) and no more than 6½ ft (2.0 m) above the electrical datum plane »*551.77(D)*«. The electrical datum plane is defined in Article 100 as a specified vertical distance above the normal high-water level at which electrical equipment can be installed and electrical connections can be made.

H Underground service, feeder, branch-circuit, and recreational vehicle site feeder-circuit conductors must be installed according to 551.80(A) and (B).

Caution

GFCI protection shall be provided as required in 210.8(B). GFCI protection shall not be required for other than 125-volt, 15- and 20-ampere receptacles installed in recreational vehicle site equipment »*551.71(F)*«. The 20-ampere receptacle required at each RV site with electrical supply shall not be required to be tamper-resistant in accordance with 406.12 »*551.71(A)*«.



Note

The weather-resistant requirement for 50-ampere 125/250-volt receptacles shall become effective January 1, 2026 »***551.71(C)***«.

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Note

In all areas subject to vehicular movement, open conductors of not over 1000 volts, nominal, shall have a vertical clearance of at least 18 ft (5.5 m) and a minimum 3-ft (900-mm) horizontal clearance. In all other areas, clearances shall conform to 235.360 and 235.361 ***»551.79«***.

Marinas and Boatyards

Marina and Boatyard Requirements

The following items shall be connected to an equipment grounding conductor run with the circuit conductors in the same raceway, cable, or trench:

1. **Metal boxes, metal cabinets, and all other metal enclosures**
2. **Metal frames of utilization equipment**
3. **Grounding terminals of grounding-type receptacles *»555.37(A)«***

Branch-circuit insulated equipment grounding conductors shall terminate either at a grounding terminal in a remote panelboard, in other distribution equipment, or in the main service-equipment grounding terminal *»555.37(D)«*.

A feeder supplying a remote panelboard, or other distribution equipment, shall have an insulated equipment grounding conductor extending from a service-equipment grounding terminal to a grounding terminal in the remote panelboard or other distribution equipment *»555.37(C)«*.

Floating dock or marina service equipment shall be located on land no closer than 5 ft (1.5 m) horizontally from and adjacent to the structure served, but not on or in the structure itself or any other floating structure. Service equipment shall be at least 12 in. above the electrical datum plane *»555.4«*.

General lighting and other loads shall be calculated in accordance with Part III of Article 220, and in addition, the demand factors set forth in 220.120 shall be permitted for each service and/or feeder supplying receptacles that provide shore power for boats *»555.6«*.

A Article 555 covers wiring and equipment installation in the areas comprising fixed (or floating) piers, wharfs, docks, floating buildings, and other areas in marinas, boatyards, boat basins, boathouses, yacht clubs, boat condominiums, docking facilities associated with one-family dwellings, two-family dwellings, multifamily dwellings, and residential condominiums; any multiple docking facility or similar occupancies; and facilities that are used, or intended for use, for the purpose of repair, berthing, launching, storage, or fueling of small craft and the moorage of floating buildings *»555.1«*.

B Electrical equipment enclosures installed on piers above deck level shall be securely and substantially supported by structural members, independent of any conduit connected to them. If enclosures are not attached to mounting surfaces by means of external ears or lugs, the internal screw heads shall be sealed to prevent seepage of water through mounting holes *»555.31(A)«*.

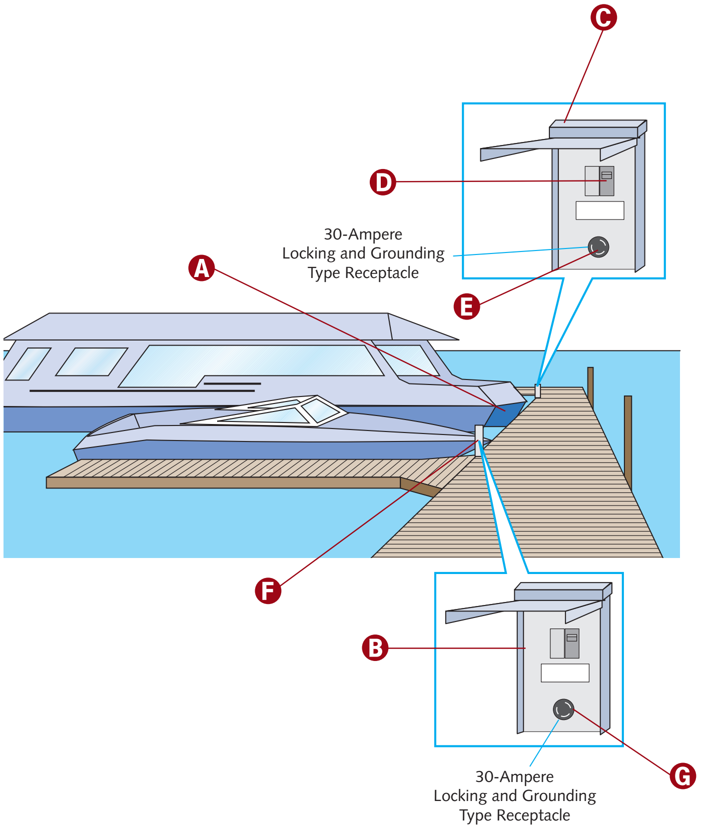
C Receptacles intended to supply shore power to boats shall be housed in marina power outlets listed for wet locations, listed enclosures protected from the weather, or listed weatherproof enclosures. The weatherproof integrity of the assembly shall not be affected when the receptacles are in use with any properly configured booted or nonbooted attachment plug/cap inserted *»555.33(A)(1)«*.

D Disconnecting means shall be provided to isolate each boat from its supply connection(s) *»555.36«*. The disconnecting means shall consist of a circuit breaker, switch, or both, and shall be properly identified as to which receptacle it controls *»555.36(A)«*.

E Receptacles providing shore power for boats shall be rated at least 30 amperes and shall be of the single type *»555.33(A)(4)«*.

F Electrical equipment enclosures on piers shall be located so as not to interfere with mooring lines *»555.31(B)«*.

G Receptacles rated 30 and 50 amperes shall be of the locking and grounding type *»555.33(A)(4)(a)«*. Receptacles rated 60 amperes or higher shall be of the pin and sleeve type *»555.33(A)(4)(b)«*.


C
D
30-Ampere Locking and Grounding Type Receptacle
A
E
F
B
G
30-Ampere Locking and Grounding Type Receptacle

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Note

GFCI and GFPE must be provided as specified in 555.35(A) through (D).

Caution

Each single receptacle supplying shore power to boats shall be supplied from a marina power outlet or panelboard by an individual branch circuit of the voltage class and rating corresponding to the receptacle's rating »*555.33(A)(3)*«.

Floating Buildings

Floating Building Provisions

The service equipment for a floating building shall be located on land no closer than 5 ft (1.5 m) horizontally and adjacent to the structure served, but not on or in the structure itself or any other floating structure. Service equipment shall be at least 12 in. above the electrical datum plane »*555.4*«.

The main overcurrent protective device that feeds the floating structure shall have ground-fault protection not exceeding 100 milliamperes (mA). Ground fault protection of each individual branch or feeder circuit shall be permitted as a suitable alternative »*555.53*«.

One set of service conductors can serve multiple service equipment sets »*555.50*«.

Each floating building shall be supplied by a single set of feeder conductors from its service equipment »*555.51*«. Where the floating building has multiple occupancy, each occupant can be supplied by a single set of feeder conductors extended from the occupant's service equipment to the occupant's panelboard »*555.51 Exception*«.

Flexibility of the wiring system shall be maintained between the floating buildings and the supply conductors. All wiring shall be installed so that water surface motion and changes in water level do not result in unsafe conditions »*555.52(A)*«.

LFMC, or LFNC with approved fittings, is allowed for feeders and wherever flexible connections are required. Extra-hard usage portable power cable listed for both wet locations and sunlight resistance is permitted for a feeder to a floating building where flexibility is required. Other raceways suitable for the location can be installed where flexibility is not required »*555.52(B)*«.

In accordance with 555.54, grounding at floating buildings shall comply with the following:

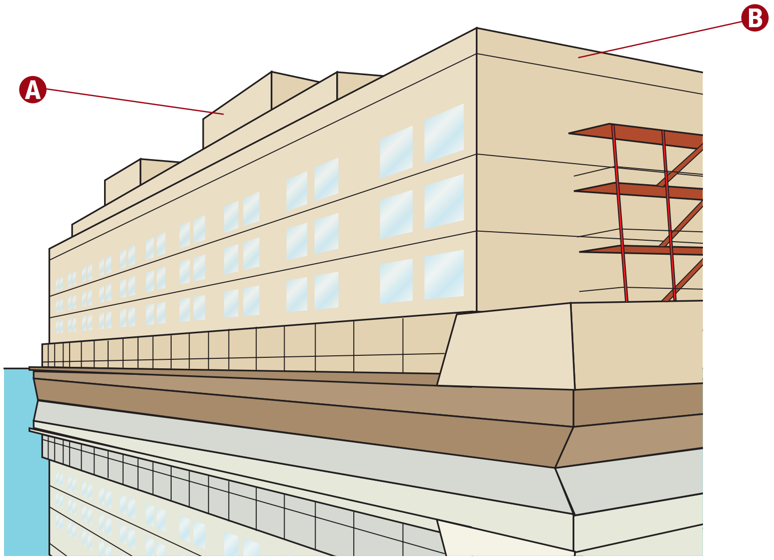
(A) Grounding of both electrical and nonelectrical parts in a floating building shall be through connection to a grounding bus in the building panelboard.

(B) The equipment grounding conductor shall be installed with the feeder conductors and connected to a grounding terminal in the service equipment.

(C) The equipment grounding conductor shall be an insulated copper conductor with a continuous outer finish that is either green or green with one or more yellow stripes. For conductors larger than 6 AWG, or where multiconductor cables are used, reidentification of conductors as allowed in 250.119(B)(2)b and (B)(2)c shall be permitted.

(D) The grounding terminal in the service equipment shall be grounded by connection through an insulated grounding electrode conductor to a grounding electrode on shore.

The grounded circuit conductor (neutral) shall be an insulated conductor identified in conformance with 200.6. The neutral conductor shall be connected to the equipment grounding terminal in the service equipment, and, except for that connection, it shall be insulated from the equipment grounding conductors, equipment enclosures, and all other grounded parts. The neutral conductor terminals in the panelboard and



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in ranges, clothes dryers, counter-mounted cooking units, and the like shall be insulated from the enclosures »*555.55*«.

Where cord-connected appliances require grounding, it shall be accomplished by means of an equipment grounding conductor in the cord and a grounding-type attachment plug »*555.56(B)*«.

Ⓐ Part III of Article 555 covers floating buildings.

Ⓑ **Floating building:** A building that floats on water, is moored in a permanent location, and has a premises wiring system served through connection by permanent wiring to an electrical supply system not located on the premises »*Article 100*«.

Note

All electrical system enclosures and exposed metal parts shall be connected to the grounding bus »***555.56(A)***«.

Caution

All metal parts in contact with the water, all metal piping, and all non-current-carrying metal parts that are likely to become energized and that are not connected to a branch circuit or feeder equipment grounding conductor, shall be connected to the grounding bus in the panelboard using solid copper conductors; insulated, covered, or bare; not smaller than 8 AWG. Connections to bonded parts shall be made in accordance with 250.8 »*555.13*«.

Summary

- Article 518 covers all buildings, portions of buildings, or structures intentionally designed for the assembly of 100 or more persons.
- Meeting rooms with a floor area of 1000 ft^2 (93 m^2) or less shall have outlets installed in accordance with 210.65.
- Article 520 provisions apply theaters, audience areas of motion picture and television studios, performance areas, and similar locations.
- While Article 520, Part II applies to fixed stage switchboards, Part IV applies to portable on-stage switchboards.
- Stage equipment, other than switchboards (fixed and portable), are covered in Article 520, Parts III and V, respectively.
- Theater dressing room provisions are located in Article 520, Part VI (520.71 through 520.74).
- Article 525 covers the installation of portable wiring and equipment for carnivals, circuses, exhibitions, fairs, traveling attractions, and similar functions, including wiring in (or on) all structures.
- Motion picture/television studios and remote locations are located in Article 530.
- The provisions of Article 540 apply to motion picture projector rooms, motion picture projectors, and associated equipment.
- Article 545 covers requirements for manufactured buildings and relocatable structures.
- The requirements of Article 547 apply to agricultural buildings (all or in part), or adjacent areas of like nature as specified in 547.1(A) and (B).
- Article 550 (mobile homes, manufactured homes, and mobile home parks) is divided into three parts: Part I (general), Part II, (mobile and manufactured homes), and Part III (services and feeders).
- The provisions of Article 551 cover the electrical conductors and equipment installed within (or on) recreational vehicles, the conductors connecting recreational vehicles to an electrical supply, and the installation of electrical equipment and devices within a recreational vehicle park.
- Article 555 covers wiring and equipment installation in the areas comprising fixed (or floating) piers, wharfs, floating buildings, docks, and other areas in marinas, boatyards, boat basins, boathouses, and similar occupancies designed (or planned) for repair, berthing, launching, storage, or fueling of small craft and the moorage of floating buildings.
- Requirements pertaining to floating buildings are in Article 555, Part III.

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Unit 18 Competency Test

***NEC*® Reference** **Answer**

___________ ___________ 1. A(n) ___________ is any building that is of closed construction and is made or assembled in manufacturing facilities on or off the building site for installation, or assembly and installation on the building site, other than manufactured homes, mobile homes, park trailers, or recreational vehicles.

___________ ___________ 2. Every recreational vehicle site with electrical supply shall be equipped with recreational vehicle site supply equipment with at least ___________ 20-ampere, 125-volt weather-resistant receptacle.

___________ ___________ 3. Outdoor mobile home disconnecting means shall be installed so the bottom of the enclosure containing the disconnecting means is not less than ___________ ft above finished grade or the working platform.

___________ ___________ 4. A(n) ___________ is an assembly containing one male and two female cord connectors used to connect two loads to one branch circuit.

___________ ___________ 5. Equipment enclosures, boxes, conduit bodies, and fittings installed in areas of agricultural buildings where excessive ___________ could be present shall be designed to minimize the entrance of ___________.

___________ ___________ 6. All exposed lamps in theater dressing or makeup areas including rooms, where they are less than ___________ ft from the floor, shall be equipped with open-end guards riveted to the outlet box cover or otherwise sealed or locked in place.

___________ ___________ 7. In exhibition halls used for display booths, as in trade shows, the temporary wiring shall be permitted to be installed in accordance with Article ___________.

___________ ___________ 8. In RV parks, a minimum of ___________ % of all recreational vehicle sites with electrical supply shall be equipped with a 30-ampere, 125-volt receptacle.

___________ ___________ 9. A(n) ___________ is a factory-assembled structure or structures transportable in one or more sections that are built on a permanent chassis and designed to be used as a dwelling without a permanent foundation where connected to the required utilities, and includes the plumbing, heating, air-conditioning, and electric systems contained therein.

___________ ___________ 10. The service equipment for a floating building, dock, or marina shall be located on land ___________, but not on or in the structure itself or any other the floating structure.

___________ ___________ 11. Fixed stage switchboards in television studios shall be ___________ but shall not be required to be located on or adjacent to the stage.

___________ ___________ 12. A means to disconnect each portable structure from all ungrounded conductors shall be provided for each carnival ride. The disconnecting means shall be located within sight and within ___________ ft of the operator's station.

___________ ___________ 13. Each motion picture projector, floodlight, spotlight, or similar equipment shall have clear working space not less than ___________ in. wide on each side and at the rear of the equipment.

___________ ___________ 14. The overall length of a mobile home power-supply cord, measured from the end of the cord, including bared leads, to the face of the attachment plug cap shall not be less than ___________ ft and shall not exceed ___________ ft.

___________ ___________ 15. A 15-ampere duplex receptacle installed in a television audience seating area can be supplied by a ___________-ampere branch-circuit.

I. 15

II. 20

III. 30

a) II only b) I only c) either I or II d) I, II, or III

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NEC® Reference **Answer**

____________ ____________ 16. Single receptacles that provide shore power for boats shall be rated not less than ____________ amperes.

____________ ____________ 17. In a multiple occupancy building, occupancy of any room or space for assembly purposes by less than ____________ persons in a building of other occupancy, and incidental to such other occupancy, shall be classified as part of the other occupancy.

____________ ____________ 18. In an RV park, open conductors of not over 1000 volts, nominal, shall have a horizontal clearance of not less than ____________ ft and a vertical clearance of not less than ____________ ft in all areas subject to recreational vehicle movement.

____________ ____________ 19. Manufactured building service-entrance conductors shall be installed after erection at the building site unless the ____________ is known prior to manufacture.

____________ ____________ 20. In a fixed stage switchboard in a theater, the circuit supplying a solid-state dimmer shall not exceed ____________ volts between conductors unless the dimmer is listed specifically for higher voltage operation.

____________ ____________ 21. The service equipment shall be mounted in a readily accessible outdoor location, and ____________ the mobile home it serves.

____________ ____________ 22. Conductors supplying outlets for arc and xenon projectors, in motion picture projection rooms, of the professional type shall not be smaller than ____________ and shall have an ampacity not less than the projector current rating.

____________ ____________ 23. Each recreational vehicle site electrical service shall be calculated on the basis of not less than ____________ volt-amperes per site equipped with 50-ampere, 208Y/120-volt, or 120/240-volt supply facilities; and ____________ volt-amperes per site equipped with only 20-ampere supply facilities that are not dedicated to tent sites.

____________ ____________ 24. Every recreational vehicle site equipped with a ____________ shall also be equipped with a 30-ampere, 125-volt receptacle.

____________ ____________ 25. A ____________ is a building that floats on water, is moored in a permanent location, and has a premises wiring system served through connection by permanent wiring to an electrical supply system not located on the premises.

____________ ____________ 26. The power supply to the mobile home shall be a feeder assembly consisting of not more than one listed ____________-ampere mobile power-supply cord or a permanently installed feeder.

____________ ____________ 27. Portable structures at carnivals shall be maintained not less than ____________ ft in any direction from overhead conductors operating at 600 volts or less, except for the conductors supplying the portable structure.

____________ ____________ 28. A professional-type projector is a type of projector using ____________ film that has a minimum width of ____________ in. and has on each edge ____________ perforations per inch, or a type using carbon arc, xenon, or other light source equipment that develops hazardous gases, dust, or radiation.

____________ ____________ 29. In closed construction of manufactured buildings, cables shall be permitted to be secured only at cabinets, boxes, or fittings where ____________ or smaller conductors are used and protection against physical damage is provided.

____________ ____________ 30. All cables installed in agricultural buildings shall be secured within ____________ in. of each cabinet, box, or fitting.

____________ ____________ 31. A minimum of ____________ % of existing and ____________ % of all new recreational vehicle sites with electrical supply shall each be equipped with a 50-ampere, 125/250-volt receptacle.

____________ ____________ 32. Footlights, border lights, and proscenium side lights, in theaters, shall be arranged so that no branch circuit supplying such equipment will carry a load exceeding ____________.

____________ ____________ 33. A meeting room that is not more than 1000 ft^2 with any floor dimension that is at least ____________ ft or greater in any direction and that has a floor area of at least 215 ft^2 (20 m^2) shall have at least one floor receptacle outlet, or at least one floor outlet to serve receptacle(s), located at a distance not less than ____________ ft from any fixed wall for each 215 ft^2 (20 m^2) or major portion of floor space.

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Unit 19

Section Five: Special Occupancies, Areas, and Equipment

Specific Equipment

Objectives

After studying this unit, the student should be able to:

- summarize electric sign and outline lighting system requirements, including neon and skeleton tubing.
- clarify manufactured wiring system provisions.
- explain how to properly install office partition wiring (power, communication, etc.).
- recall electric vehicle charging system stipulations.
- explain in detail information technology equipment requirements.
- describe where to find requirements for installing receptacle outlets for sensitive electronic equipment.
- summarize provisions relating to fire pumps.
- clarify elevator, dumbwaiter, escalator, moving walk, platform lift, and stairway chairlift requirements.
- define terms pertinent to swimming pools, fountains, and similar installations.
- describe what constitutes an equipotential bonding grid (for permanently installed pools) and what items must be bonded to the grid.
- recall equipment, panelboard, receptacle, and lighting (including underwater lighting) provisions pertaining to permanently installed swimming pools.
- define the term storable swimming pool and know the applicable requirements.
- summarize spa and hot tub provisions.
- explain where to find requirements for pools and tubs for therapeutic use in health care facilities, gymnasiums, athletic training rooms, and similar areas.
- recall the fundamental hydromassage bathtub provisions.

Introduction

Bringing this text to a close, this unit addresses a wide variety of electrical equipment requirements. *NEC*® Chapter 6 is the basis for numerous equipment illustrations throughout this unit. While most of the articles of Chapter 6 are covered here, four additional articles are described under Unit 17—Industrial Locations. Those articles are 610 (“Cranes and Hoists”), 630 (“Electric Welders”), 669 (“Electroplating”), and 670 (“Industrial Machinery”). Some of the less commonly used articles are not referenced.

Beginning with “Pipe Organs” (650), this unit recounts some of the many Chapter 6 articles. Subsequently described in illustrative detail (with corresponding article numbers in parentheses) are “Electric Signs and Outline Lighting” (600); “Manufactured Wiring Systems” (604); “Office Furnishings” (605); “Electric Vehicle Power Transfer System” (625); “Audio Signal Processing, Amplification, and Reproduction Equipment” (640); “Information Technology Equipment” (645); “Sensitive Electronic Equipment” (647); and “Fire Pumps” (695). Next, this unit devotes several illustrations to Article 620’s topics: “Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts.” Finally, the expansive subject of “Swimming Pools, Fountains, and Similar Installations” (Article 680) is introduced. Because Article 680 covers a broad range of equipment and installation applications, a significant number of illustrations have been dedicated to these requirements. It is imperative that the reader have a thorough understanding of the words and phrases found in Article 100 relating specifically to swimming pools, fountains, and similar locations. One particularly notable definition is that of **storable swimming wading, or immersion pool**. A misconception held by many is that a storable pool is, in simple terms, any aboveground swimming pool. Observe, however, that a storable pool is intended to be stored when not in use and designed for ease of relocation. While some of the smaller aboveground pools fall within this parameter, many, if not most, cannot easily be relocated or stored. It must be concluded, therefore, that any aboveground pool that cannot be easily drained and moved qualifies as a permanently installed pool and must be compliant with Article 680, Parts I and II. Storable spas and hot tubs have a similar definition. While space constraints prohibit an all-encompassing discussion of these provisions, the more predominant features are illustrated and discussed. Because of the potentially fatal nature of mistakes, study this unit carefully together with Article 680 when installing or wiring a pool, spa, hydromassage bathtub, or similar item.

As throughout this text, state or local jurisdictions may alter electrical requirements. Obtain a copy of any additional rules and regulations for your specific area.

Equipment

Pipe Organs

Installations of digital/analog-sampled sound production technology and associated audio signal processing, amplification, reproduction equipment, and wiring installed as part of a pipe organ shall comply with the appropriate Article 640 provisions »*650.3(A)*«.

Installations of optical fiber cables shall be in accordance with Parts I and V of Article 770 »*650.3(B)*«.

DC power shall be supplied by a listed dc power supply with a maximum output of 30 volts »*650.4*«. Class 1 power-limited power supplies are often utilized in pipe organ applications »*650.4 Informational Note*«.

The installation of the dc power supply shall comply with either of the following: (1) the dc power supply shall be double insulated or (2) the metallic case of the dc power supply shall be bonded to the input equipment grounding conductor »*650.5*«.

The minimum conductor size shall be not less than 28 AWG for electronic signal circuits, and at least 26 AWG for electromagnetic valve supply and the like. The minimum conductor size of a main common-return conductor in the electromagnetic supply shall be 14 AWG or larger »*650.6(A)*«.

Conductors shall have thermoplastic or thermosetting insulation »*650.6(B)*«.

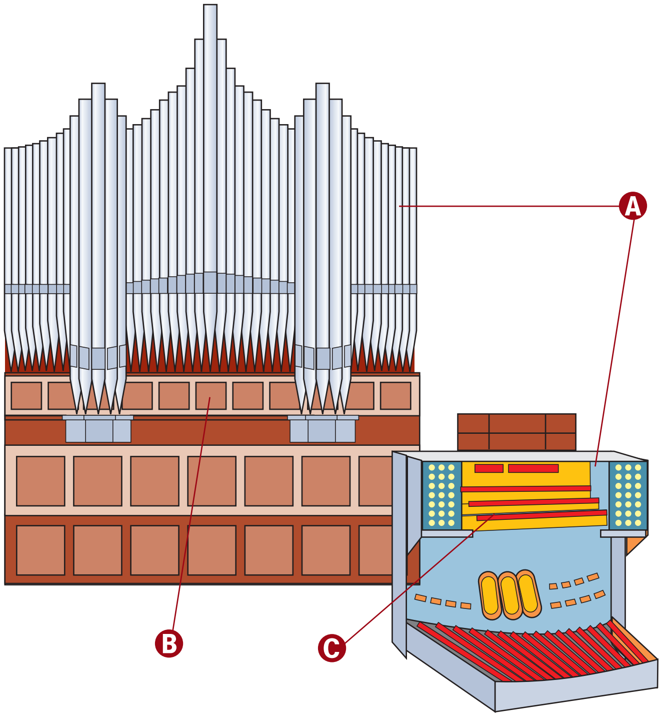
Except for the common-return conductor and conductors inside the organ proper, the organ sections and the console conductors shall be cabled. An additional covering can enclose both cable and common-return conductors. Alternately, a separate common-return conductor is allowed to contact the cable »*650.6(C)*«.

Each cable shall have an outer covering, either overall or on individual subassemblies of grouped conductors. Tape is an acceptable covering. If not housed in metal raceway, the covering shall be flame-retardant or the cable/cable subassembly shall be wrapped by closely wound listed fireproof tape »*650.6(D)*«.

Securely fastened cables can attach directly to the organ structure without insulating supports. Splices shall not be required to be enclosed in boxes or other enclosures. Control equipment and busbars connecting common-return conductors shall be permitted to be attached directly to the organ structure without insulation supports. Abandoned cables that are not terminated at equipment shall be identified with a tag of sufficient durability to withstand the environment involved »*650.7*«.

Arrange circuits so that 20 AWG through 28 AWG conductors are protected from overcurrent by an overcurrent device rated at no more than 6 amperes. Other conductor sizes shall be protected in accordance with their ampacity. A common-return conductor does not require overcurrent protection »*650.8*«.

A Article 650 covers electrically operated pipe organ circuits and components employed for the control of the keyboards and of the sounding apparatus, typically organ pipes »*650.1*«. The typical pipe organ is a very large musical instrument that is built as part of a building or structure »*650.1 Informational Note*«.



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B A pipe organ sounding apparatus is the sound-producing part of a pipe organ, including, but not limited to, pipes, chimes, bells, the pressurized air (wind)-producing equipment (blower), associated controls, and power equipment »*Article 100*«.

C A pipe organ is a musical instrument that produces sound by driving pressurized air (called wind) through pipes selected via a keyboard »*Article 100*«.

Note

An electronic organ is a musical instrument that imitates the sound of a pipe organ by producing sound electronically »***Article 100***«. Most new electronic organs produce sound digitally and are called digital organs »***Article 100 Informational Note to the definition of electronic organ***«.

Caution

The wiring of the pipe organ shall be within the lockable enclosure (organ chamber) where the exterior pipes shall be permitted to form part of the enclosure »*650.9*«. Access to the pipe organ sounding apparatus and the associated circuitry is restricted by an enclosure. In most pipe organ installations, exterior pipes form part of the enclosure. In other installations, the pipes are covered by millwork that permits the passage of sound »*650.9 Informational Note*«.

Electric Signs and Outline Lighting

Other than lamps and neon tubing, live parts shall be enclosed. An additional enclosure is not required for transformers and power supplies provided with an integral enclosure, including a primary and secondary circuit splice enclosure »*600.8*«.

Signs and outline lighting systems with lampholders for incandescent lamps shall be marked to indicate the maximum allowable lamp wattage per lampholder. The markings shall be permanently installed, in letters at least ¼ in. (6 mm) high, and shall be located where visible during relamping »*600.4(C)*«.

Other than branch circuits that supply neon tubing installations, branch circuits that supply signs and outline lighting systems shall not exceed a 20-ampere rating »*600.5(C)(2)*«.

The wiring method supplying signs and outline lighting systems shall terminate within a sign, an outline lighting system enclosure, a suitable box, a conduit body, or panelboard »*600.5(D)(1)*«.

Metal or nonmetallic poles used to support signs can enclose supply conductors »*600.5(D)(3)*«.

If operated by external electronic or electromechanical controllers, sign or outline lighting systems shall have a disconnecting means located within sight of the controller or within the controller enclosure. The disconnecting means shall disconnect both the sign (or outline lighting system) and the controller from all ungrounded supply conductors. The disconnecting means shall be designed so that no pole can be operated independently and shall be lockable in accordance with 110.25 »*600.6(A)(3)*«. Where the disconnecting means is not located within sight of the controller, a permanent field-applied marking identifying the location of the disconnecting means shall be applied to the controller in a location visible during servicing »*600.6(A)(3) Exception*«.

A Each sign and outline lighting system, feeder conductors, or branch circuit(s) supplying a sign, outline lighting system, or skeleton tubing shall be controlled by an externally operable switch (or circuit breaker) that opens all ungrounded conductors and controls no other load »*600.6*«. The disconnecting means shall be within sight of the sign or outline lighting system that it controls. If out of the line of sight from any energizable section, the disconnecting means shall be lockable in accordance with 110.25. A permanent field-applied marking identifying the location of the disconnecting means shall be applied to the sign in a location visible during servicing »*600.6(A)(2)*«.

B Article 600 covers the installation of conductors, equipment, and field wiring for electric signs, retrofit kits, and outline lighting, regardless of voltage. All installations and equipment using neon tubing, such as signs, decorative elements, skeleton tubing, or art forms, are covered by Article 600 »*600.1*«.

C Signs and outline lighting systems shall be listed and labeled; marked with the manufacturer's name, trademark or other identification; and input voltage, and current rating »*600.4(A)*«. The markings required in 600.4(A) and listing labels shall be visible after installation and shall be permanently applied in a location visible prior to servicing. The marking shall be permitted to be installed in a location not viewed by the public »*600.4(D)*«.

D Signs and outline lighting system equipment in wet locations, unless of the listed watertight type, shall be weatherproof and, if necessary, have drain holes in accordance with 600.9(D)(1) through (3) »*600.9(D)*«.

E Metal equipment of signs, outline lighting, and skeleton tubing systems shall be grounded by connection to the equipment grounding conductor of the supply branch circuit(s) or feeder using the types of equipment grounding conductors specified in 250.118 »*600.7(A)(1)*«. See additional grounding and bonding provisions in 600.7(A) and (B).

F Unless protected from physical damage, sign or outline lighting system equipment shall be at least 14 ft (4.3 m) above areas accessible to vehicles »*600.9(A)*«.

G Except for portable cord-connected signs, all signs, outline lighting, skeleton tubing systems, and retrofit kits shall be marked to indicate that field wiring and installation instructions are required »*600.4(E)*«.

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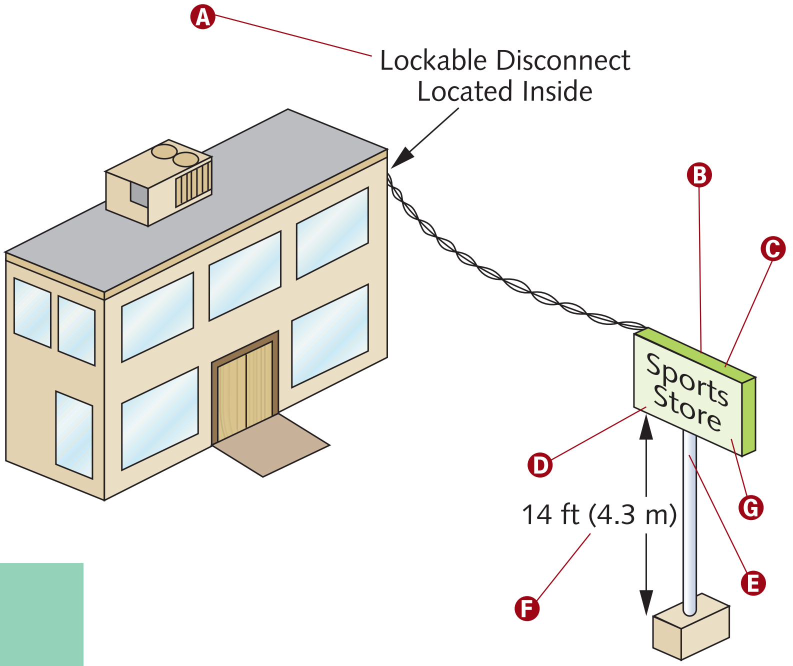
Note

Each commercial building and occupancy accessible to pedestrians shall have at least one accessible outlet at every tenant space entrance for sign or outline lighting system use. The outlet(s) shall be supplied by an exclusively dedicated branch circuit rated 20 amperes (or more). A sign or outline lighting outlet shall not be required at entrances for deliveries, service corridors, or service hallways that are intended to be used only by service personnel or employees ***»600.5(A)«***. A disconnecting means for a sign, outline lighting system, or controller shall be marked to identify the sign, outline lighting system, or controller it controls unless meeting the exception ***»600.5(B)«***.

Note

The sign disconnecting means shall be permitted to be located in accordance with 600.6(A)(1), (A)(2), (A)(3), or (A)(4) ***»600.6(A)«***. Unless meeting one of the two exceptions, the disconnect shall be located at the point the feeder circuit or branch circuit(s) supplying a sign or outline lighting system enters a sign enclosure, a sign body, or a pole in accordance with 600.5(D)(3). The disconnect shall open all ungrounded conductors where it enters the enclosure of the sign or pole ***»600.6(A)(1)«***.



Caution

Fixed, mobile, or portable electric signs, section signs, outline lighting photovoltaic (PV) powered signs, and retrofit kits, regardless of voltage, shall be listed and labeled, provided with installation instructions, and installed in conformance with that listing, unless otherwise approved by special permission *»600.3«*. As a system, outline lighting does not have to be listed when it consists of listed luminaires wired in accordance with Chapter 3 *»600.3(B)«*.

Neon and Skeleton Tubing

Article 600, Part II provisions apply to field-installed skeleton tubing, field-installed secondary circuits, outline lighting, and field-installed retrofit kits. These requirements are in addition to Part I requirements *»600.30«*.

Neon tubing: Electric-discharge luminous tubing, including cold cathode luminous tubing, that is manufactured into shapes to illuminate signs, forming letters (or parts thereof), skeleton tubing, outline lighting, and other decorative elements or art forms, and filled with various inert gases *»Article 100«*.

Skeleton tubing: Neon tubing that is, itself, the sign or outline lighting and is not attached to an enclosure or sign body *»Article 100«*.

The supply branch circuits of neon tubing installations shall not be rated in excess of 30 amperes *»600.5(C)(1)«*.

Neon tubing, other than listed, dry-location, portable signs that are readily accessible to pedestrians shall be protected from physical damage *»600.9(B)«*.

A Sharp bends in insulated conductors shall be avoided *»600.32(D)«*.

B Only one conductor shall be installed per run of conduit or tubing *»600.32(A)(2)«*.

C Conductors shall be installed in rigid metal conduit, intermediate metal conduit, liquidtight flexible nonmetallic conduit, flexible metal conduit, liquidtight flexible metal conduit, electrical metallic tubing, metal enclosures, on insulators in metal raceways, or other equipment listed for use with neon secondary circuits over 1000 volts *»600.32(A)(1)«*.

D Metal equipment of signs, outline lighting, and skeleton tubing systems shall be grounded by connection to the equipment grounding conductor of the supply branch circuit(s) or feeder using the types of equipment grounding conductors specified in 250.118 *»600.7(A)(1)«*.

E Secondary conductors shall be separated from each other and from all objects other than insulators or neon tubing by at least 1½ in. (38 mm) of space. GTO cable, installed in metal conduit or tubing, requires no spacing between the cable insulation and the conduit or tubing *»600.32(E)«*.

F All conductors' insulation shall extend no less than 2½ in. (65 mm) beyond the metal conduit or tubing *»600.32(G)«*.

G Neon tubing's length and design shall not cause a continuous overcurrent beyond the capacity of the transformer or electronic power supply *»600.41(A)«*.

H Neon tubing secondary conductor(s) shall be supported within 6 in. (150 mm) of the electrode connection »*600.42(D)*«.

I Connections shall be made by twisting the wires together, by use of a connection device, or by use of an electrode receptacle. Connections shall be electrically and mechanically secure and shall be within an enclosure listed for the purpose »*600.42(C)*«.

Caution

Equipment having an open circuit voltage exceeding 1000 volts shall not be installed in (or on) dwelling occupancies »*600.32(I)*«.

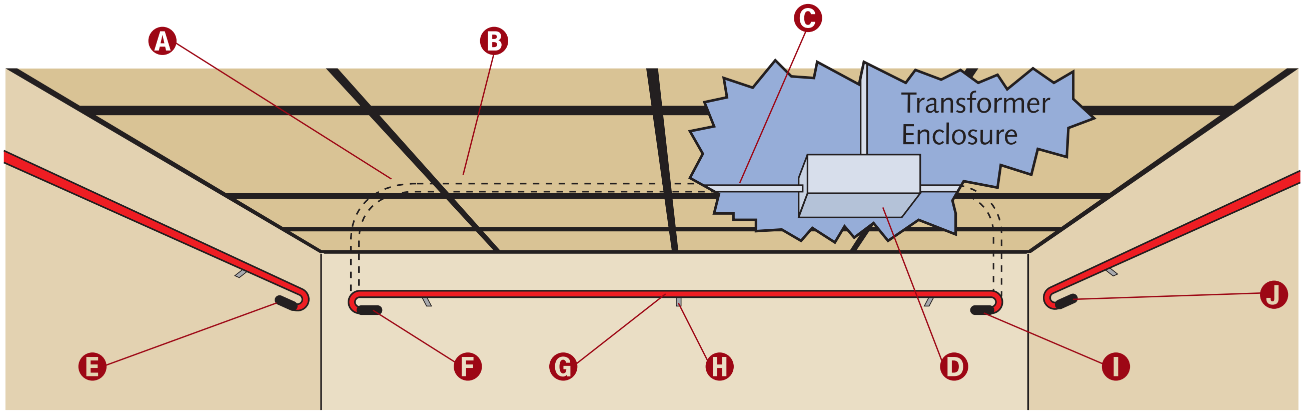
J Electrode terminals shall not be accessible to unqualified persons »*600.42(B)*«.

Note

Conductor provisions pertaining to this illustration apply to neon secondary circuit conductors over 1000 volts, nominal (600.32). Section 600.31 covers neon secondary circuit conductors of 1000 volts or less, nominal.

Note

Ballasts, transformers, and electronic power supplies must meet the requirements in 600.21 through 600.24.



Manufactured Wiring Systems

Where listed for the purpose, manufactured wiring system assemblies can be used in outdoor locations »*604.10 Exception No. 2*«.

Conduit shall be listed FMC, liquidtight flexible metal conduit, liquidtight flexible nonmetallic conduit, or electrical metallic tubing, containing nominal 600-volt 8 to 12 AWG insulated copper-clad aluminum or copper conductors with a copper-clad aluminum or copper equipment grounding conductor (bare or insulated) equal in size to the ungrounded conductor »*604.100(A)(2)*«. (See Exceptions No. 1 through 3.)

Hard-usage flexible cord (minimum 12 AWG conductors) can be part of a listed factory-made assembly, not exceeding 6 ft (1.8 m) in length, as a transition method between manufactured wiring system components and utilization equipment, not permanently secured to the building structure. The cord must be visible for the entire length, shall not be subject to physical damage, and shall be provided with identified strain relief »*604.100(A)(3)*«. (See exception for listed electric-discharge luminaires.)

A Article 604 provisions apply to field-installed wiring using off-site manufactured subassemblies for branch circuits, remote-control circuits, signaling circuits, and communications circuits in accessible areas »*604.1*«.

B The type of cable, flexible cord, or conduit shall be clearly marked on each section »*604.100(B)*«.

C Receptacles and connectors shall be (1) of the locking type, uniquely polarized and identified for the purpose, and (2) part of a listed assembly appropriate for the system »*604.100(C)*«.

D Manufactured wiring systems shall be secured and supported in accordance with the applicable cable or conduit article for the cable or conduit type employed »*604.7*«.

E Ceiling grid-supported wires shall not be used to support cables (and raceways). Secure support shall be provided via wires and associated fittings *and* shall be installed in addition to the ceiling grid support wires »*300.11(B)*«. (This illustration does not show cable supports.)

F A **manufactured wiring system** is a system containing component parts that are assembled in the process of manufacture and cannot be inspected at the building site without damage or destruction to the assembly and used for the connection of luminaires, utilization equipment, continuous plug-in type busways, and other devices »*Article 100*«. Manufactured wiring systems and associated components shall be listed »*604.6*«.

G Cable shall be one of the following:

(1) Listed Type AC cable containing nominal 600-volt, 8- to 12-AWG insulated copper-clad aluminum or copper conductors.

(2) Listed Type MC cable containing nominal 600-volt, 8- to 12-AWG insulated copper-clad aluminum or copper conductors.

(3) Other cables as listed in 722.135, 800.113, and 830.179 shall be permitted in manufactured wiring systems for wiring of equipment within the scope of their respective articles »*604.100(A)(1)*«.

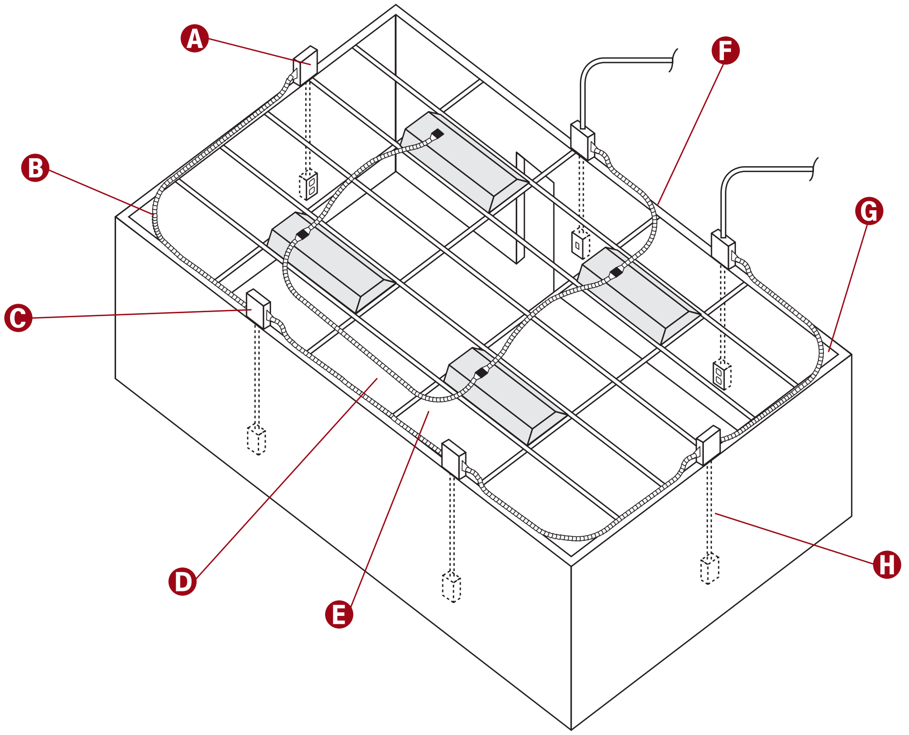
H Manufactured wiring systems are permitted in accessible and dry locations, and in ducts, plenums, and other air-handling spaces where listed for this application and installed per 300.22 »*604.10*«. In concealed spaces, one end of tapped cable can extend into hollow walls for direct switch/outlet termination points »*604.10 Exception No. 1*«.

Caution

All connector openings shall be designed to prevent inadvertent contact with live parts or capped to effectively close the connector openings »*604.100(C)*«.

Note

Manufactured wiring systems shall not be used where limited by the applicable article in Chapter 3 for the wiring method used in its construction »***604.12***«.



Office Furnishings

Wiring systems shall be identified as suitable for providing power for lighting accessories and utilization equipment used within office furnishings. A wired partition shall not extend from floor to ceiling »*605.3*«.

Office furnishings of the freestanding type (not fixed) shall be permitted to be connected to the building electrical system by one of the wiring methods of Chapter 3 »*605.8*«.

Individual office furnishings of the freestanding type, or groups of individual office furnishings that are electrically connected, are mechanically contiguous, and do not exceed 30 ft (9.0 m) when assembled, shall be permitted to be

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connected to the building's electrical system by means of a single flexible cord and plug, provided *all* of the following conditions are met:

(A) The flexible power-supply cord shall be of the extra-hard usage type, with 12 AWG or larger conductors, with an insulated equipment grounding conductor, and not more than 2 ft (600 mm) in length.

(B) The receptacle(s) supplying power shall be on a separate circuit serving only the office furnishing and no other loads and shall be located not more than 12 in. (300 mm) from the office furnishing to which it is connected.

(C) An individual office furnishing or groups of interconnected individual office furnishings shall not contain more than thirteen 15-ampere, 125-volt receptacle. For purposes of this requirement, a receptacle is considered (1) up to two (simplex) receptacles provided within a single enclosure and that are within 1 ft (0.3 m) of each other or (2) one duplex receptacle.

(D) An individual office furnishing or groups of interconnected office furnishings shall not contain multiwire circuits »*605.9*«.

Ⓐ Article 605 covers electrical equipment, lighting accessories, and wiring systems that connect to, are contained within, or are installed on office furnishings »*605.1(A)*«.

Ⓑ Office furnishing are defined as cubicle panels, partitions, study carrels, workstations, desks, shelving systems, and storage units that may be mechanically and electrically interconnected to form an office furnishing system »*Article 100*«.

Ⓒ The electrical connection between office furnishings shall be either a flexible assembly identified for use with office furnishings or shall be permitted to be installed using flexible cord, provided *all* of the following conditions are met: (1) the cord is extra-hard usage type with 12 AWG or larger conductors and shall have an insulated equipment grounding conductor; (2) the office furnishings are mechanically contiguous; (3) the cord is not longer than necessary for maximum positioning of the office furnishing but is in no case to exceed 2 ft (600 mm); and (4) the cord terminates at an attachment plug-and-cord connector with strain relief »*605.5*«.

Ⓓ Lighting equipment shall be listed, labeled, and identified for use with office furnishings and shall comply with 605.6(A), (B), and (C) »*605.6*«.

Ⓔ All conductors and connections shall be contained within wiring channels (metal or other material) identified as suitable for the conditions of use. These channels shall be free of projections or other conditions that may damage conductor insulation »*605.4*«.

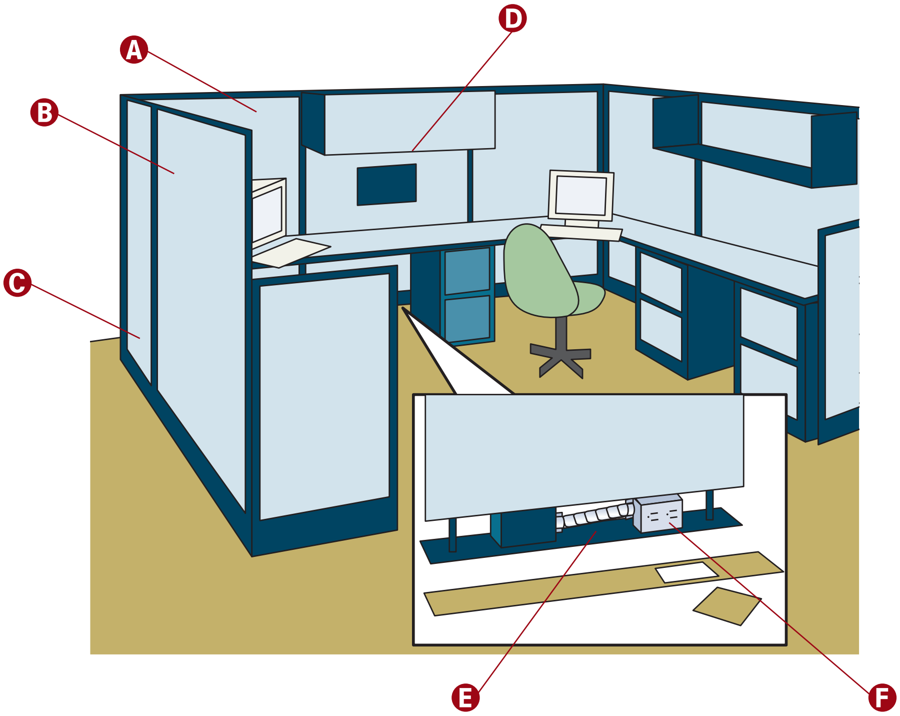
Ⓕ Chapters 5, 6, and 7 may supplement or modify the requirements in Chapters 1 through 7. Chapters 1 through 4 apply generally »*90.3*«.

Note

Office furnishings that are fixed (secured to building surfaces) shall be permanently connected to the building electrical system by one of Chapter 3's wiring methods »*605.7*«.

Caution

Each multiwire branch circuit shall be provided with a means that will simultaneously disconnect all ungrounded conductors at the point where the branch circuit originates »*210.4(B)*«.



Electric Vehicle Power Transfer System

Charge power converter: The device used to convert energy from the power grid to a high-frequency output for wireless power transfer »*Article 100*«.

Electric vehicle power export equipment (EVPE): The equipment, including the outlet on the vehicle, that is used to provide electrical power at voltages greater than or equal to 30 Vac or 60 Vdc to loads external to the vehicle, using the vehicle as the source of supply »*Article 100*«. As stated in the informational note under this definition, electric vehicle power export equipment and electric vehicle supply equipment are sometimes contained in one piece of equipment, sometimes referred to as a bidirectional EVSE or bidirectional WPTE.

Output cable to the primary pad: A multi-conductor, shielded cable assembly consisting of conductors to carry the high-frequency energy and any status signals between the charger power converter and the primary pad »*Article 100*«.

Power-supply cord: An assembly consisting of an attachment plug and length of flexible cord connected to utilization equipment »*Article 100*«.

Primary pad: A device external to the electric vehicle that transfers power via the contactless coupling as part of a wireless power transfer system »*Article 100*«.

Wireless power transfer (WPT): The transfer of electrical energy from a power source to an electrical load via magnetic fields by a contactless means between a primary and a secondary device »*Article 100*«.

Wireless power transfer equipment (WPTE): Equipment installed specifically for the purpose of transferring energy between the premises wiring and the electric vehicle without physical electrical contact »*Article 100*«. Wireless power transfer equipment requirements are in Article 625, Part IV.

Overcurrent protection for feeders and branch circuits supplying EVSE and WPTE, including bidirectional EVSE and WPTE shall be sized for continuous duty and shall have a current rating of not less than 125% of the maximum load of the equipment. Where noncontinuous loads are supplied from the same feeder, the overcurrent device shall have a current rating of not less than the sum of the noncontinuous loads plus 125% of the continuous loads »*625.41*«.

Mechanical ventilation shall not be required where electric vehicle storage batteries are used, or where the equipment is listed for charging electric vehicles indoors without ventilation »*625.52(A)*«.

Ⓐ Unless specifically listed and marked for the location, the electric vehicle supply equipment's coupling means shall be stored or located at a height of not less than 18 in. (450 mm) above the floor level for indoor locations and 24 in. (600 mm) above the grade level for outdoor locations. This requirement does not apply to portable EVSE constructed in accordance with 625.44(A) »*625.50*«.

Ⓑ Article 625 covers the electrical conductors and equipment connecting an electric vehicle to premises wiring for the purposes of charging, power export, or bidirectional current flow »*625.1*«.

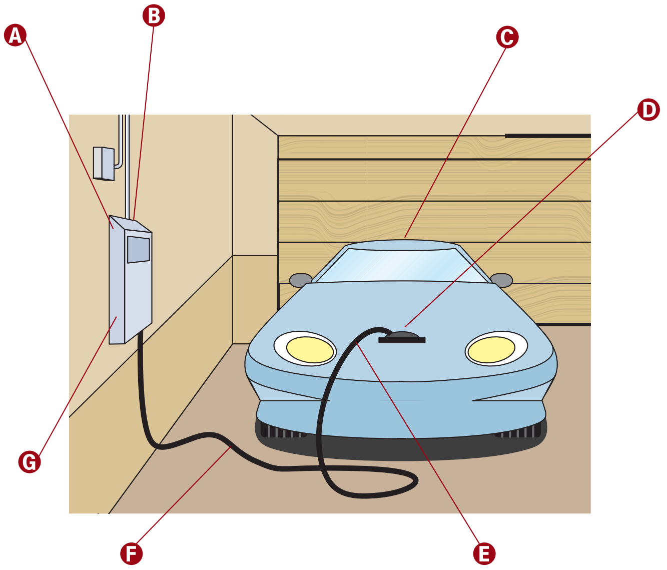
Ⓒ **Electric vehicle:** An automotive-type vehicle for on-road use, such as passenger automobiles, buses, trucks, vans, neighborhood electric vehicles, electric motorcycles, and the like, primarily powered by an electric motor that draws current from a rechargeable storage battery, fuel cell, photovoltaic array, or other source of electric current. Plug-in hybrid electric vehicles (PHEV) are electric vehicles having a second source of motive power »*Article 100*«. Off-road, self-propelled electric mobile equipment, such as industrial trucks, hoists, lifts, transports, golf carts, airline ground support equipment, tractors, boats, and the like, are not considered electric vehicles »*Informational Note under the definition of electric vehicle in Article 100*«.

Ⓓ **Electric vehicle connector:** A device that, when electrically coupled (conductive or inductive) to an electric vehicle inlet, establishes an electrical connection to the electric vehicle for the purpose of power transfer and information exchange. »*Article 100*«.

Ⓔ **Output cable to the electric vehicle:** An assembly consisting of a length of flexible EV cable and an electric vehicle connector (supplying power to the electric vehicle) »*Article 100*«.

Ⓕ The overall usable length of the cable shall not exceed 25 ft (7.5 m) unless equipped with a cable management system that is part of the listed electric vehicle supply equipment »*625.17(C)*«.

Ⓖ **Electric vehicle supply equipment (EVSE):** Includes the conductors (ungrounded, grounded, and equipment grounding conductors), electric vehicle connectors, attachment plugs, personnel protection equipment, and all other fittings, devices, power outlets, or apparatus purposely installed to transfer energy between the premises wiring and the electric vehicle »*Article 100*«.



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Note

Electric vehicle power transfer system equipment for the purposes of charging, power export, or bidirectional current flow shall be listed »*625.6*«.

Caution

Each outlet installed for the purpose of supplying EVSE greater than 16 amperes or 120 volts shall be supplied by an individual branch circuit. »*625.40*«.

Warning

Mechanical ventilation (such as a fan) shall be provided where the equipment is listed for charging electric vehicles that require ventilation for indoor charging. The ventilation shall include both supply and exhaust equipment and shall be permanently installed and located to intake from, and vent directly to, the outdoors. Positive-pressure ventilation systems shall be permitted only in vehicle charging buildings or areas that have been specifically designed and approved for that application. Mechanical ventilation requirements shall be determined using one of the methods found in 625.52(B)(1) through (4) »*625.52(B)*«.

Audio Signal Processing, Amplification, and Reproduction Equipment

Grounding of separately derived systems with *60 volts to ground* shall meet 647.6 requirements »*640.7(B)*«.

Equipment access shall not be denied by accumulated wires and cables that prevent panel removal, including suspended ceiling panels »*640.5*«.

Wireways and auxiliary gutters shall be connected to an equipment grounding conductor(s), to an equipment bonding jumper, or to the grounded conductor where permitted or required by 250.92(B)(1) or 250.142. Where the wireway or auxiliary gutter does not contain power-supply wires, the equipment grounding conductor shall not be required to be larger than 14 AWG copper or its equivalent. Where the wireway or auxiliary gutter contains power-supply wires, the equipment grounding conductor shall not be smaller than specified in 250.122 »*640.7(A)*«.

Isolated grounding-type receptacles are permitted as described in 250.146(D), as well as for the implementation of other Article 250 compliant technical power systems. For separately derived systems with 60 volts to ground, the branch-circuit equipment grounding conductor shall be terminated per 647.6(B) »*640.7(C)*«.

Portable equipment: Equipment fed with portable cords or cables and intended for movement from one place to another »*Article 100*«.

Temporary equipment: Portable wiring and equipment used with events of a transient or temporary nature where equipment removal is presumed at the event's conclusion »*Article 100*«.

Technical power system (often referred to as *tech power*): An electrical distribution system where the equipment grounding conductor is isolated from the premises grounded conductor and the premises equipment grounding conductor except at a single grounded termination point within a branch-circuit panelboard, at the originating (main breaker) branch-circuit panelboard, or at the premises grounding electrode »*Article 100*«.

Grouped (or bundled) insulated conductors of different systems, in close physical contact within the same raceway (or other enclosure), or in portable cords (or cables), shall comply with 300.3(C)(1) »*640.8*«.

Ⓐ Article 640 covers equipment and wiring for audio signal generation, recording, processing, amplification and reproduction; distribution of sound; public address; speech input systems; temporary audio system installations; and electronic musical instruments (including organs). This encompasses audio systems subject to Article 517, Part VI; and Articles 518, 520, 525, and 530 »*640.1(A)*«. Article 640 does not cover the installation and wiring of fire and burglary alarm signaling devices »*640.1(B)*«.

Ⓑ **Loudspeaker:** Equipment that converts an alternating-current (ac) electric signal into an acoustic signal. »*Article 100*«.

Ⓒ **Mixer:** Equipment used to combine and level-match a multiplicity of electronic signals, as from microphones, electronic instruments, and recorded audio »*Article 100*«.

Ⓓ **Audio signal processing equipment:** Electrically operated equipment that produces, processes, or both electronic signals that, when appropriately amplified and reproduced via loudspeaker, output an acoustic signal within the range of normal human hearing (typically 20 Hz to 20 kHz). Within Article 640, the terms *equipment* and *audio equipment* are equivalent to audio signal processing equipment »*Article 100*«.

Ⓔ **Audio system:** The totality of equipment and interconnected wiring used to fabricate a fully functional audio signal processing, amplification, and reproduction system »*Article 100*«.

Ⓕ **Equipment rack:** A framework for the support, enclosure, or both, of equipment; can be portable or stationary »*Article 100*«.

Note

The accessible portion of abandoned audio distribution cables shall be removed »*640.6(B)*«.

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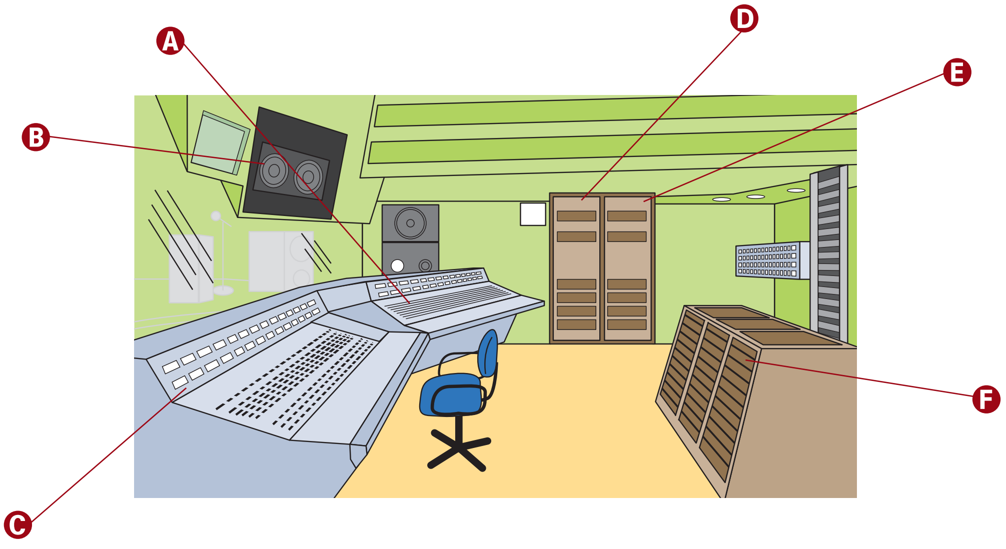
Caution

Cables installed exposed on the surface of ceilings and sidewalls shall be supported in such a manner that the audio distribution cables will not be damaged by normal building use. Such cables shall be secured by straps, staples, cable ties, hangers, or similar fittings designed and installed so as not to damage the cable. The installation shall conform to 300.4 and 300.11(A) »*640.6(A)*«.



Information Technology Equipment

A An approved means shall be provided to disconnect power to all electronic equipment in the information technology equipment room or in designated zones within the room. There shall also be a similar approved means to disconnect the power to all dedicated HVAC systems serving the room or designated zones and shall cause all required fire/smoke dampers to close. Unless the disconnecting means is for a critical operations data system as covered in 645.10(B), the disconnecting means shall comply with the following:

(1) Remote disconnect means controls shall be located at approved locations readily accessible in case of fire to authorized personnel and emergency responders.

(2) The remote disconnect means controls for the control of electronic equipment power and HVAC systems shall be grouped and identified. A single means to control both systems shall be permitted.

(3) Where multiple zones are created, each zone shall have an approved means to confine fire or products of combustion to within the zone.

(4) Additional means to prevent unintentional operation of remote disconnect controls shall be permitted »*645.10* and *645.10(A)*«.

B Article 645 covers equipment, power-supply wiring, and equipment interconnected wiring, as well as grounding of information technology equipment and systems in an information technology equipment room »*645.1*«.

C The alternative wiring methods to Chapter 3 and Parts I and II of Article 725 for signaling wiring and Parts I and V of Article 770 for optical fiber cabling shall be permitted provided all of the conditions listed in 645.4(1) through (6) are met »*645.4*«.

D Information technology equipment shall be permitted to be connected to a branch circuit by power-supply cords:

(1) Power-supply cords shall not exceed 15 ft (4.5 m).

(2) Power cords shall be listed and a type permitted for use on listed information technology equipment or shall be constructed of listed flexible cord and listed attachment plugs and cord connectors of a type permitted for information technology equipment.

(3) Plugs and receptacles used to connect the power-supply cords shall be listed and identified for the system voltage and current applied »*645.5(B)*«.

E The branch-circuit conductors supplying one or more units of information technology equipment shall have an ampacity not less than 125% of the total connected load »*645.5(A)*«.

F Where the area under the floor is accessible and openings minimize the entrance of debris beneath the floor, power-supply cords, communications cables, connecting cables, interconnecting cables, cord-and-plug connections, and receptacles associated with the information technology equipment shall be permitted under a raised floor of approved construction. The installation requirement shall comply with 645.5(E)(1) through (E)(3) »*645.5(E)*«.

G Uninterruptible power supply (UPS) systems installed within the information technology equipment room, and their supply and output circuits, shall comply with 645.10 unless: (1) the installation complies with Parts I and II of Article 685, or (2) the power source is limited to 750 volt-amperes or less derived either from UPS equipment or from battery circuits integral to electronic equipment. The disconnecting means shall also disconnect the battery from its load »*645.11*«.

H One of the conditions required in order to use the alternate wiring methods in Article 645 pertains to the HVAC system. A heating/ventilating/air-conditioning (HVAC) system shall be provided in one of the methods identified in 645.4(2) a or b.

a. A separate HVAC system that is dedicated for information technology equipment use and is separated from other areas of occupancy; or

b. An HVAC system that serves other occupancies and meets all of the following: (1) also serves the information technology equipment room, (2) provides fire/smoke dampers at the point of penetration of the room boundary, and

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(3) activates the damper operation upon initiation by smoke detector alarms, by operation of the disconnecting means required by 645.10, or by both »*645.4(2)*«.

I All exposed non-current-carrying metal parts of an information technology system shall either be bonded to the equipment grounding conductor in accordance with Parts I, V, VI, VII, and VIII of Article 250 or be double-insulated. Signal reference structures, where installed, shall be bonded to the equipment grounding conductor provided for the information technology equipment. Any auxiliary grounding electrode(s) installed for information technology equipment shall be installed in accordance with 250.54 »*645.15*«.

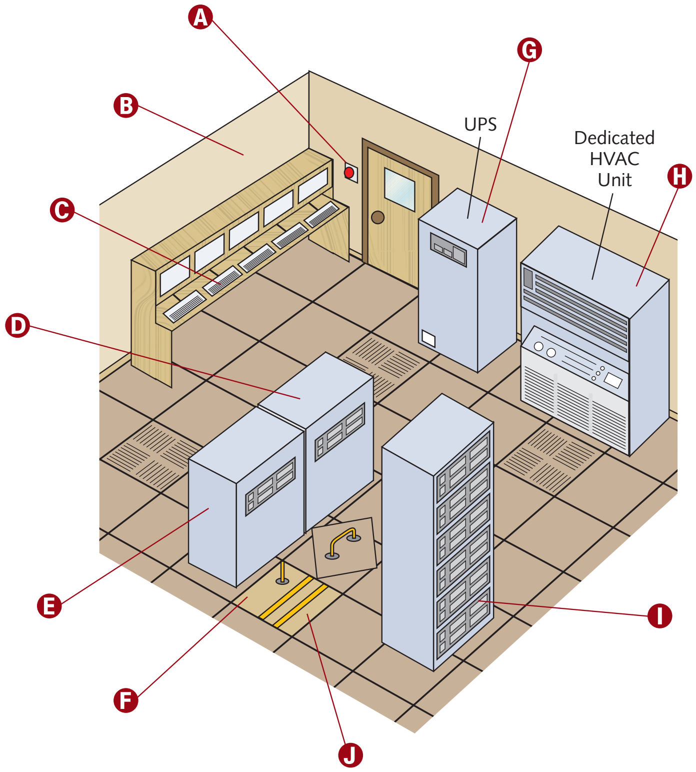
J Where installed under raised floors, it is not necessary to secure in place cables (power, communications, connecting, and interconnecting) and associated boxes, connectors, plugs, and receptacles that are listed as part of, or for, information technology equipment »*645.5(F)*«.

Note

Separately derived power systems shall be installed in accordance with Parts I and II of Article 250. Power systems derived within listed information technology equipment that supply information technology systems through receptacles or cable assemblies supplied as part of this equipment shall not be considered separately derived for the purpose of applying 250.30 »*645.14*«.

Caution

Critical operations data system(s) overcurrent protective devices shall be selectively coordinated with all supply-side overcurrent protective devices. Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system »*645.27*«.



Warning

Where exposed to physical damage, power-supply cords, branch-circuit supply conductors, and interconnecting cables shall be protected »*645.5(D)*«.

Fire Pumps

Electric motor-driven fire pumps shall have a reliable power source »*695.3*«. See 695.3(A) for individual source requirements and 695.3(B) for multiple source requirements.

A fire pump can be supplied by a separate service »*230.2(A)(1)* and *695.3(A)(1)*«.

If service or system voltage differs from the fire pump motor's utilization voltage, one or more transformers (protected by disconnecting means and overcurrent protective devices) can be installed between the system supply and the fire pump controller in accordance with 695.5(A) and (B), or with (C). Only transformers covered in (C) can supply loads unrelated to the fire pump system »*695.5*«.

Power circuits and wiring methods shall comply with the requirements in 695.6(A) through (J), and, as permitted in 230.90(A), Exception No. 4; 230.94, Exception No. 4; 240.13; 235.408; 240.4(A); and 430.31 »*695.6*«.

The location of electric motor-driven fire pump controllers and power transfer switches shall be within sight from and as close as practicable to the motors they control »*695.12(A)*«. Engine-driven fire pump controllers shall be located as close as practical to and within sight from the engines they control »*695.12(B)*«.

Fire pump controllers and power transfer switches, by location or protection, shall remain undamaged by water escaping from pumps or pump connections »*695.12(E)*«.

The disconnecting means shall be marked "Fire Pump Disconnecting Means." The minimum 1-in. (25-mm)-high letters shall be visible without opening enclosure doors or covers »*695.4(B)(3)(c)*«.

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Fire pump supply conductors on the load side of the final disconnecting means and overcurrent device(s) permitted by 695.4(B), or conductors that connect directly to an on-site standby generator, shall comply with all of the following:

(a) The conductors shall be kept entirely independent of all other wiring.

(b) The conductors shall supply only loads that are directly associated with the fire pump system.

(c) The conductors shall be protected from potential damage by fire, structural failure, or operational accident.

(d) Where routed through a building, the conductors shall be protected from fire for 2 hours using one of the following three methods: (1) the cable or raceway is encased in a minimum 2 in. (50 mm) of concrete; (2) the cable or raceway is a listed fire-resistive cable system; (3) the cable or raceway is protected by a listed electrical circuit protective system »*695.6(A)(2)*«.

Automatic protection against overloads is not allowed on power circuits. Except for protection of transformer primaries provided in 695.5(C)(2), branch-circuit and feeder conductors shall be protected against short circuit only »*695.6(C)*«.

All engine controller/battery wiring shall be protected against physical damage, being installed in accordance with the controller and engine manufacturer's instructions »*695.6(F)*«.

A All wiring from the controllers to the pump motors shall be in RMC, IMC, EMT, LFMC, or LFNC-B, listed Type MC cable with an impervious covering, or Type MI cable. Electrical connections at motor terminal boxes shall be made with a listed means of connection. Twist-on, insulation-piercing-type, and soldered wire connectors shall not be permitted to be used for this purpose. Fittings shall be listed for use in wet locations »*695.6(D)*«.

B Conductors supplying fire pump motor(s), pressure maintenance pumps, and associated accessory equipment shall have a minimum ampacity of 125% of the sum of the fire pump motor(s) and pressure maintenance motor(s) full-load current(s), plus 100% of the associated fire pump accessory equipment full-load current(s) »*695.6(B)(1)*«. Conductors supplying only fire pump motor(s) shall have a minimum rating in accordance with 430.22 and shall comply with the voltage drop requirements in 695.7 »*695.6(B)(2)*«.

C Article 695 covers the installation of (1) electric power sources and interconnecting circuits for fire pumps and (2) switching and control equipment dedicated to fire pump drivers »*695.1(A)*«.

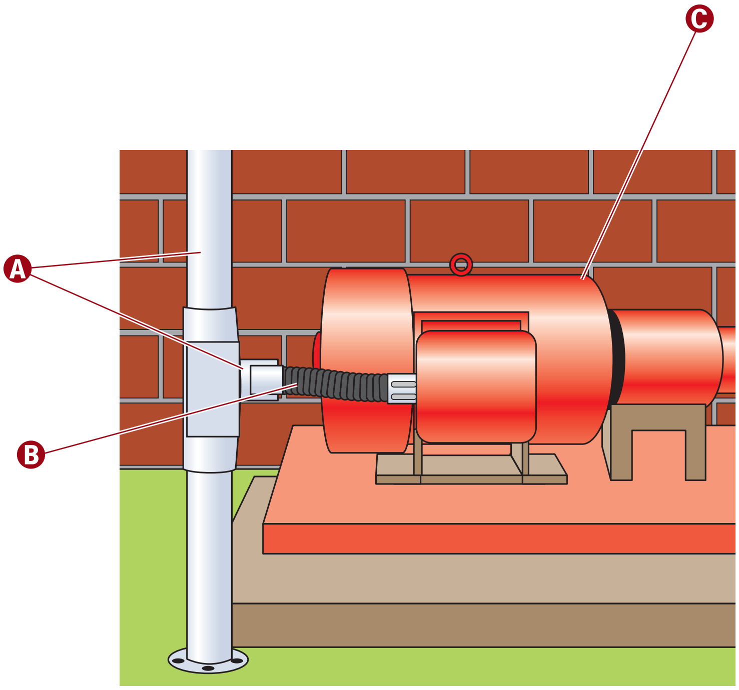
Note

Article 695 does not cover (1) the performance, maintenance, and acceptance testing of the fire pump system and the system components' internal wiring, (2) the installation of pressure maintenance (jockey or makeup) pumps, (3) transfer equipment upstream of the fire pump transfer switch(es), and (4) water pumps installed in one- and two-family dwellings used for fire suppression »*695.1(B)*«.

Conductors used to supply fire pump equipment, if provided with service equipment and installed per service-entrance conductor requirements, can be connected to the supply side of the service disconnecting means »*230.82(5)*«.

Caution

Overcurrent protective devices shall be selectively coordinated with all supply-side overcurrent protective devices. Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system »*695.3(C)(3)*«.



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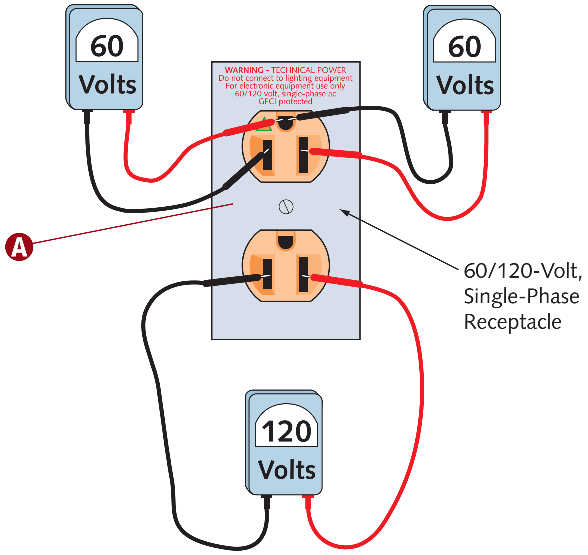
Sensitive Electronic Equipment

Technical Power-System Receptacles

A Article 647 covers the installation and wiring of sensitive electronic equipment that is connected to a separately derived system operating at 120 volts line-to-line and 60 volts to ground »*647.1*«.

Note

While isolated ground receptacles are permitted as described in 250.146(D), the branch-circuit equipment grounding conductor shall be terminated per 647.6(B) »*647.7(B)*«.



60 Volts
60 Volts
WARNING - TECHNICAL POWER
Do not connect to lighting equipment
For electronic equipment use only
60/120 volt, single-phase ac
GFCI protected
A
60/120-Volt, Single-Phase Receptacle
120 Volts

Receptacle Installation

Where receptacles are used as a means of connecting equipment, all of the conditions in 647.7(A)(1) through (4) shall be met »*647.7(A)*«.

A All receptacle outlet strips, adapters, receptacle covers, and faceplates shall be marked as required by 647.7(A)(2):

WARNING—TECHNICAL POWER

Do not connect to

lighting equipment.

For electronic equipment use only.

60/120 V 1ø ac

GFCI protected.

B All 125-volt receptacles used for 60/120-volt technical power shall be uniquely configured and identified for use with this class of system »*647.7(A)(4)*«.

C All 15- and 20-ampere receptacle outlets shall be GFCI protected »*647.7(A)(1)*«.

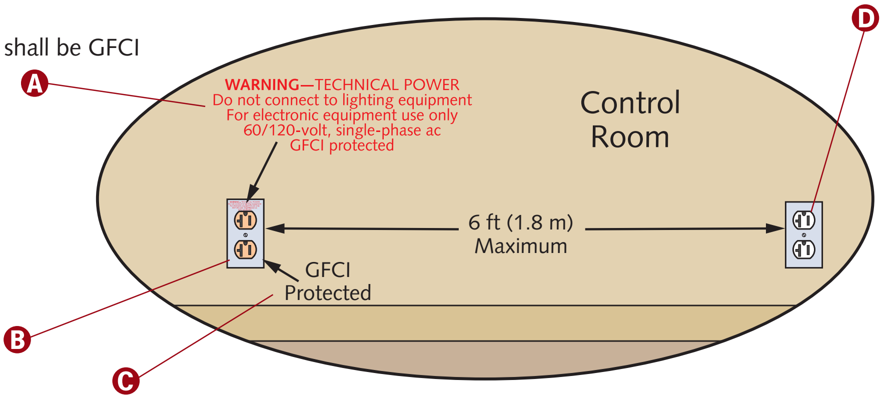
Caution

Clear markings on all junction box covers shall indicate the distribution panel and the system voltage »*647.4(B)*«.

D A 125-volt, single-phase, 15- or 20-ampere-rated receptacle having one of its current-carrying poles connected to a grounded circuit conductor shall be located within 6 ft (1.8 m) of all permanently installed 15- or 20-ampere-rated 60/120-volt technical power-system receptacles »*647.7(A)(3)*«.

Note

The warning sign(s) or label(s) shall comply with 110.21(B) »*647.7(A)(2)*«.



D
A
WARNING—TECHNICAL POWER
Do not connect to lighting equipment
For electronic equipment use only
60/120-volt, single-phase ac
GFCI protected
Control Room
6 ft (1.8 m) Maximum
GFCI Protected
B
C

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Separately Derived Systems with 60 Volts to Ground

A Standard single-phase panelboards and distribution equipment with higher voltage ratings can be used »*647.4(A)*«.

B The transformer secondary center tap of the 60/120-volt, 3-wire system shall be grounded as provided in 250.30 »*647.6(A)*«.

C A separately derived 120-volt, single-phase, 3-wire system with 60 volts on each of two ungrounded conductors to an equipment grounding conductor can be used to reduce objectionable noise in sensitive electronic equipment locations provided that (1) the system is installed only in commercial or industrial occupancies, (2) the system's use is restricted to areas under close supervision by qualified personnel, and (3) all requirements in 647.4 through 647.8 are met »*647.3*«.

D Common-trip, two-pole circuit breakers or a combination two-pole fused disconnecting means that are identified for use at the system voltage shall be provided for both ungrounded conductors in all feeders and branch circuits »*647.4(A)*«.

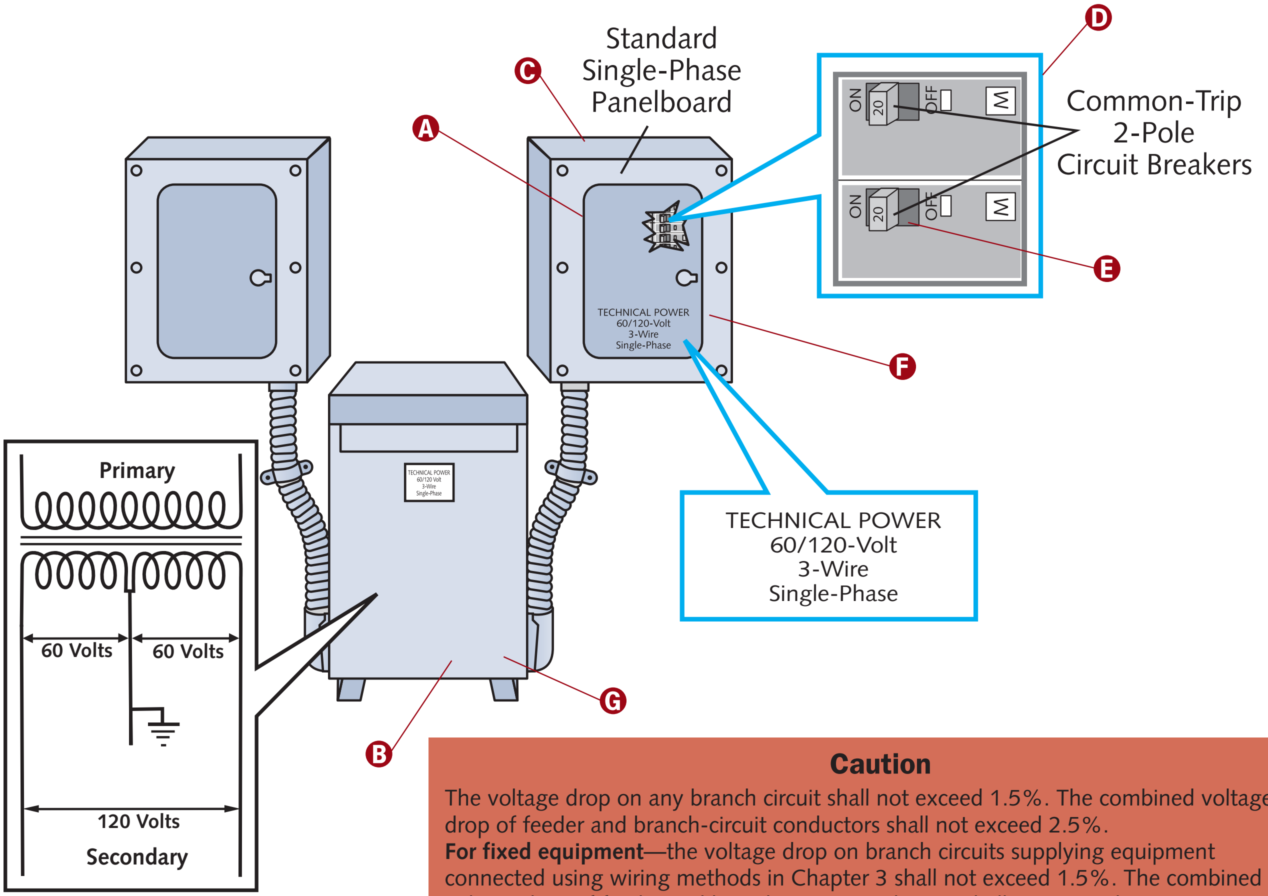
E Branch circuits and feeders shall be provided with a means to simultaneously disconnect all ungrounded conductors »*647.4(A)*«.

F The system shall be clearly marked on the panel's face or inside the panel's door »*647.4(A)*«.

G Permanently wired utilization equipment and receptacles shall be grounded via an equipment grounding conductor, run with the circuit conductors, to an equipment grounding bus (prominently marked "Technical Equipment Ground") in the branch-circuit panelboard. The equipment grounding bus shall be connected to the grounded conductor on the line side of disconnecting means supplied by the separately derived system. The equipment grounding conductor shall be sized as specified in Table 250.122 and run with the feeder conductors. The technical equipment grounding bus shall not be required to be bonded to the panelboard enclosure »*647.6(B)*«.

Note

All feeders and branch-circuit conductors installed under 647.4 shall be identified as to system at all splices and terminations by color, marking, tagging, or equally effective means. The means of identification shall be posted at each branch-circuit panelboard and at the building's disconnecting means »*647.4(C)*«.



Caution

The voltage drop on any branch circuit shall not exceed 1.5%. The combined voltage drop of feeder and branch-circuit conductors shall not exceed 2.5%.

For fixed equipment—the voltage drop on branch circuits supplying equipment connected using wiring methods in Chapter 3 shall not exceed 1.5%. The combined voltage drop of feeder and branch-circuit conductors shall not exceed 2.5%.

For cord-connected equipment—the voltage drop on branch circuits supplying receptacles shall not exceed 1%. For the purposes of making this calculation, the load connected to the receptacle outlet shall be considered to be 50% of the branch-circuit rating. The combined voltage drop of feeder and branch-circuit conductors shall not exceed 2.0% »*647.4(D)*«.

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Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway ChairLifts

General

Control system: Overall system governing starting, stopping, direction of motion, acceleration, speed, and retardation of the moving member »*Article 100*«.

Motion controller: Electrical device(s) for that portion of the control system governing acceleration, speed, retardation, and stopping of the moving member »*Article 100*«.

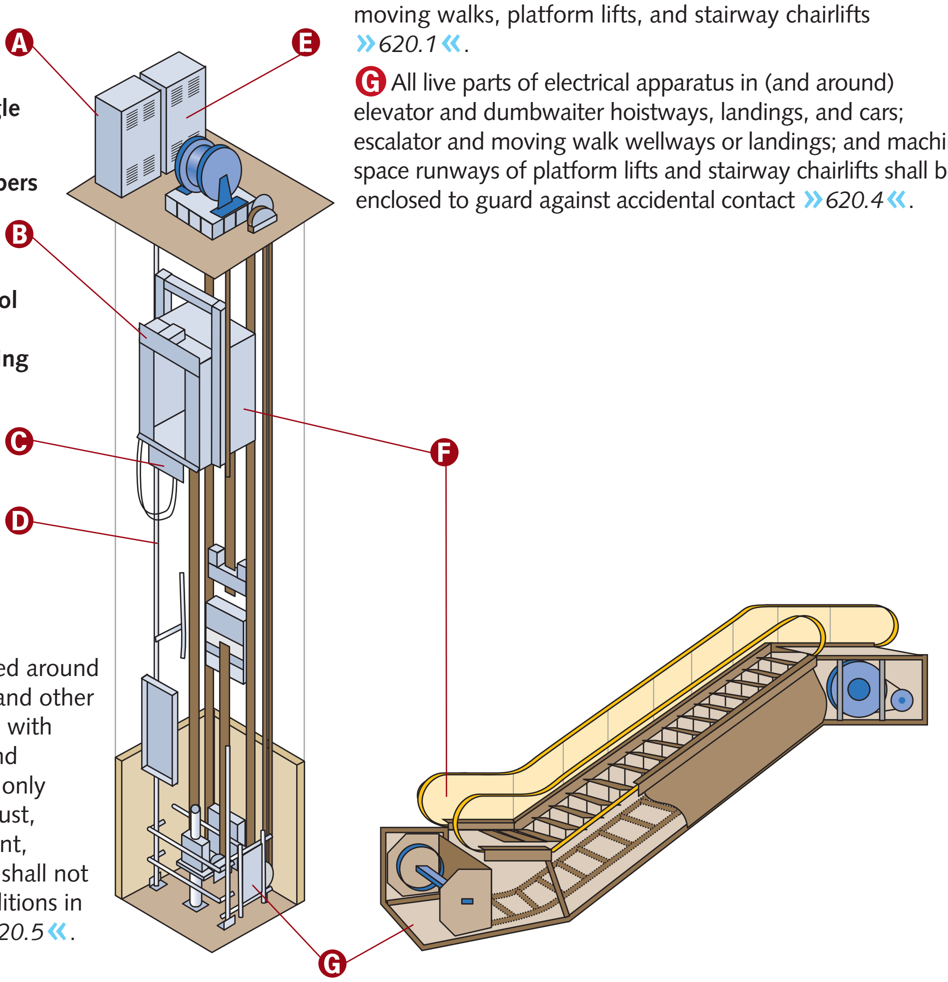
Motor controller: Any switch or device that is normally used to start and stop a motor by making and breaking the motor circuit current »*Article 100*«.

Operation controller: Electric device(s) for that portion of the control system that initiates starting, stopping, and direction of motion in response to an operating device's signal »*Article 100*«.

Door operator controller and door motor branch circuits, as well as feeders to motor controllers, driving machine motors, machine brakes, and motor-generator sets shall have a circuit voltage of 1000 volts or less »*620.3(A)*«.

Operating device: Devices used to activate the operation controller, such as the car switch, push buttons, key, or toggle switch(es) »*Article 100*«.

Conductors, cables, and optical fibers within hoistways, escalator and moving walk wellways, platform lifts, stairway chairlift runways, machinery spaces, control spaces, in/on cars, and machine/control rooms (exclusive of traveling cables connecting the car or counterweight and hoistway wiring) shall be installed in RMC, IMC, EMT, PVC, or wireways; or shall be Type MC, MI, or AC cable unless otherwise permitted in 620.21(A) through (C) »*620.21*«.



A Working space shall be provided around controllers, disconnecting means, and other electrical equipment in accordance with 110.26(A). Where maintenance and supervision conditions ensure that only qualified persons will examine, adjust, service, and maintain the equipment, 110.26(A) clearance requirements shall not be required where any of the conditions in 620.5(A) through (D) are met »*620.5*«.

B Circuit voltage of heating/air-conditioning equipment branch circuits located on the elevator car shall not exceed 1000 volts »*620.3(C)*«.

C Lighting circuits shall comply with Article 410 requirements »*620.3(B)*«.

D The minimum conductor size for traveling cables that feed lighting circuits is 14 AWG copper. Provided the ampacity equals or surpasses that of 14 AWG copper, 20 AWG (or larger) copper conductors are permitted in parallel. For traveling cable circuits, other than lighting, 20 AWG copper is the minimum size »*620.12(A)*«.

E The motor controller rating shall comply with 430.83. When the controller is marked as power limited, thereby limiting the available power to the motor, the rating of the controller can be less than the nominal rating of the elevator motor »*620.15*«.

F Article 620 covers the installation of electric equipment and wiring relating to elevators, dumbwaiters, escalators, moving walks, platform lifts, and stairway chairlifts »*620.1*«.

G All live parts of electrical apparatus in (and around) elevator and dumbwaiter hoistways, landings, and cars; escalator and moving walk wellways or landings; and machinery space runways of platform lifts and stairway chairlifts shall be enclosed to guard against accidental contact »*620.4*«.

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Elevator Wiring

Flexible cords and cables that are components of listed equipment used in circuits operating at 30 volts rms (or less) or 42 volts dc (or less) are permitted, provided the cords and cables are (1) supported and protected from physical damage and (2) of a jacketed and flame-retardant type »*620.21(A)(2)(c)*«.

Motor generators, machine motors, or pumping unit motors and valves that are located adjacent to, or underneath, control equipment and provided with extra-length terminal leads and are no longer than 6 ft (1.8 m) can be connected directly to controller terminal studs without regard to the carrying-capacity requirements of Articles 430 and 445. Auxiliary gutters are permitted in machine/control rooms between controllers, starters, and similar apparatus »*620.21(A)(3)(b)*«.

Existing or listed equipment conductors can be grouped together (taped or corded) without being installed in a raceway. Such cable groups should by location be protected from physical damage, being supported at intervals of 3 ft (900 mm) or less »*620.21(A)(3)(d)*«.

A FMC, LFMC, or LFNC of ⅜ in. nominal trade size or larger and no longer than 6 ft (1.8 m) can be installed between control panels and machine motors, machine brakes, motor-generator sets, disconnecting means, and pumping unit motors and valves »*620.21(A)(3)(a)*«. LFNC-B trade size ⅜ and larger, can be installed in lengths exceeding 6 ft (1.8 m) »*620.21(A)(3)(a) Exception*«.

B FMC, LFMC, or LFNC of ⅜ in. nominal trade size (or larger) and not exceeding 6 ft (1.8 m) in length, allowed for installation on cars, shall be securely fastened in an oil-free location »*620.21(A)(2)(a)*«. LFNC-B of ⅜ in. nominal trade size or larger is permitted in lengths greater than 6 ft (1.8 m) »*620.21(A)(2)(a) Exception*«.

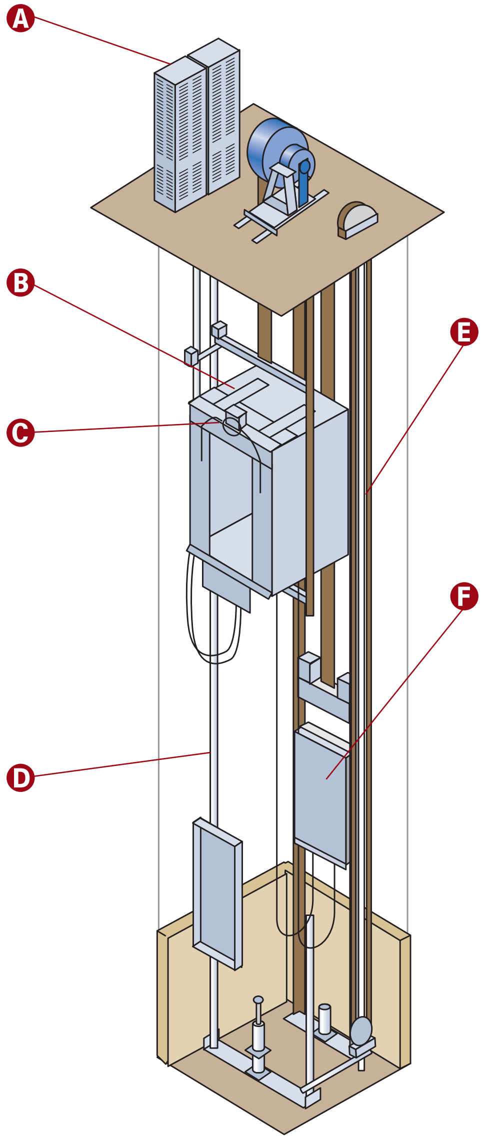
C Hard-service cords and junior hard-service cords conforming to Article 400 (Table 400.4) requirements are permitted as flexible connections between the car's fixed wiring and the car door/gate devices. Only hard-service cords are permitted as flexible connections for top-of-car operating devices or car-top work light. Devices or luminaires shall be grounded via an equipment grounding conductor run with the circuit conductors. Cables having smaller conductors as well as other insulation (jacket) types and thicknesses can serve as flexible connections between the car's fixed wiring and the car door/gate devices, if listed for this use »*620.21(A)(2)(b)*«.

D Cords and cables of listed cord- and plug-connected equipment shall not be required to be installed in a raceway »*620.21 Exception*«.

E In hoistways and pits, Types CL2P, CL2R, and CL2 cables shall be permitted, provided the cables are supported and protected from physical damage. Substitute cables for Class 2 cables installed in accordance with 722.135(E) shall be permitted »*620.21(A)(1)(a)*«.

F The following wiring methods shall be permitted on the counterweight assembly and on the car assembly in lengths not to exceed 6 ft (1.8 m): (1) flexible metal conduit; (2) liquidtight flexible metal conduit; (3) liquidtight flexible nonmetallic conduit; and (4) flexible cords and cables, or conductors grouped together and taped or corded, shall be permitted to be installed without a raceway. They shall be located to be protected from physical damage and shall be of a flame-retardant type and shall be part of one of the following:

a. Listed equipment
b. A driving machine
c. A driving machine brake »*620.21(A)(2)(d)* and *620.21(A)(4)*«.



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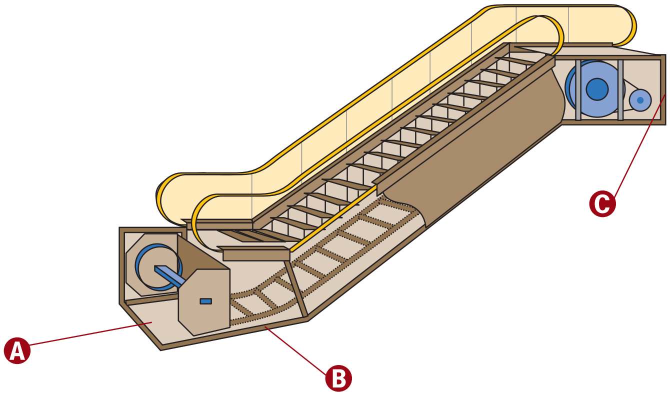
Escalator and Moving Walks Wiring

Ⓐ FMC, LFMC, or LFNC are acceptable in escalator and moving walk wellways. FMC or liquidtight flexible conduit of ⅜ inch nominal trade size is permitted in lengths of 6 ft (1.8 m) or less »*620.21(B)(1)*«. LFNC-B of ⅜ in. nominal trade size or larger can be installed in lengths greater than 6 ft (1.8 m) »*620.21(B)(1) Exception*«.

Ⓑ Types CL2P, CL2R, and CL2 cables can be installed within escalators and moving walkways provided the cables are supported and protected from physical damage. Substitute cables for Class 2 cables installed in accordance with 722.135(E) shall be permitted »*620.21(B)(2)*«.

Note
Platform lifts and stairway chairlift raceways shall be installed according to 620.21(C) provisions.

Ⓒ Hard-service cords conforming to Article 400 (Table 400.4) requirements are permitted as flexible connections on escalator and moving walk control panels and disconnecting means where the entire control panel and disconnecting means can be removed from machine spaces per 620.5 »*620.21(B)(3)*«.



Conductor Installation

Auxiliary gutters are not subject to the length restrictions of 366.10(C), or to the number of conductors per 366.22 »*620.35*«.

Ⓐ Electrical wiring, raceways, and cables used in direct connection with the elevator or dumbwaiter are permitted inside the hoistway, machine rooms, control rooms, machinery spaces, and control spaces. Wiring for signals; for communication with the car; for lighting, heating, air conditioning, and ventilating the elevator car; for fire-detecting systems; for pit sump pumps; for hoistway pit lighting; and for heating, air-conditioning, and ventilating the hoistway are allowed »*620.37(A)*«.

Ⓑ Cables or raceway supports in a hoistway, escalator/moving walk wellway, or platform lift and stairway chairlift runway shall be securely fastened to the guide rail, escalator/moving walk truss, or the hoistway, wellway, or runway construction »*620.34*«.

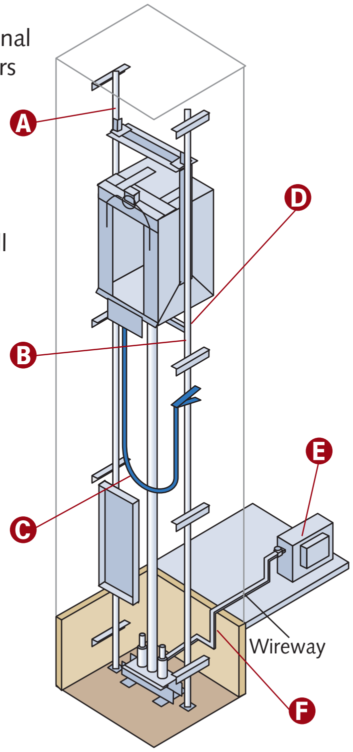
Ⓒ Optical fiber cables and conductors for operating devices, operation and motion control, power, signaling, fire, alarm, lighting, heating, and air-conditioning circuits of 1000 volts (or less) can run in the same traveling cable (or raceway) system if (1) all conductors are insulated for the maximum voltage applied to any conductor within the cable (or raceway) system and (2) all live parts of the equipment are insulated from ground for the same maximum voltage. Traveling cable or raceway shall also be permitted to include shielded pairs, coaxial cables, and other communications circuits. Type CMP-LP or CMR-LR cables complying with 800.179 shall be permitted in raceways »*620.36*«.

Ⓓ Bonding of elevator rails (car and/or counterweight) to a lightning protection system down conductor(s) is permitted. The lightning protection system down conductor(s) shall be located outside the hoistway. Elevator rails or other hoistway equipment shall not be used as the down conductor for lightning protection systems »*620.37(B)*«.

Ⓔ Feeders supplying elevator and dumbwaiter power shall be installed outside the hoistway unless (1) by special permission, elevator feeders are permitted within an existing hoistway containing no spliced conductors or (2) feeders are permitted inside the hoistway for elevators with driving machine motors located in the hoistway, on the car, or on the counterweight »*620.37(C)*«.

Ⓕ The sum of the cross-sectional area of the individual conductors in a wireway shall be no more than 50% of the wireway's interior cross-sectional area. Vertically run wireways shall be securely supported at intervals of 15 ft (4.5 m) or less and shall have a maximum of one joint between supports. Adjoining wireway sections shall be securely fastened together to form a rigid joint »*620.32*«.

Caution
Electrical equipment and wiring used for elevators, dumbwaiters, escalators, moving walks, platform lifts, and stairway lifts in garages shall comply with 511.3(A) requirements »*620.38*«.



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Branch Circuits and Traveling Cables

A At least one 125-volt, single-phase, 15- or 20-ampere duplex receptacle shall be provided in each machine room, control room or machinery space, control space, and in truss interiors where required »*620.23(C)*«.

B A separate branch circuit shall supply each elevator car's lights. The car lights branch circuit shall be permitted to supply other equipment specifically listed in 620.22(A). Required lighting shall not be connected to the load side of a ground-fault circuit interrupter »*620.22(A)*«. A separate branch circuit is required for each elevator car's air-conditioning/heating unit. Locate this branch circuit's overcurrent protective device in the elevator machine room or control room/machinery space or control space »*620.22(B)*«.

C Traveling cables shall be suspended at both the car and hoistway ends (or counterweight end if applicable), thereby reducing the strain on individual copper conductors to a minimum. Support traveling cables by any one of the following means:

1. Steel supporting member(s)
2. Looping the cables around supports for unsupported lengths less than 100 ft (30 m)
3. Suspending from the supports by a means that automatically tightens around the cable with increased tension, for unsupported lengths up to 200 ft (60 m) »*620.41*«

D Careful location of traveling cable supports can reduce to a minimum the possibility of damage due to cables contacting hoistway construction/equipment. Provide suitable guards where necessary to protect the cables against damage »*620.43*«.

E Each hoistway pit shall have at least one 125-volt, single-phase, 15- or 20-ampere duplex receptacle »*620.24(C)*«.

F The branch circuits supplying the lighting for machine rooms, control rooms, machinery spaces, control spaces, or truss interiors where required shall be separate from the branch circuits supplying the receptacles in those places. These circuits shall supply no other loads. Required lighting shall not be connected to a GFCI's load side »*620.23(A)*«. Locate the lighting switch at the machine room or control room/machinery space or control space point of entry »*620.23(B)*«.

G Metal raceways and cables of Types MC, MI, or AC attached to an elevator car shall be bonded to the metal parts of the car that are bonded to the equipment grounding conductor »*620.81*«.

Caution

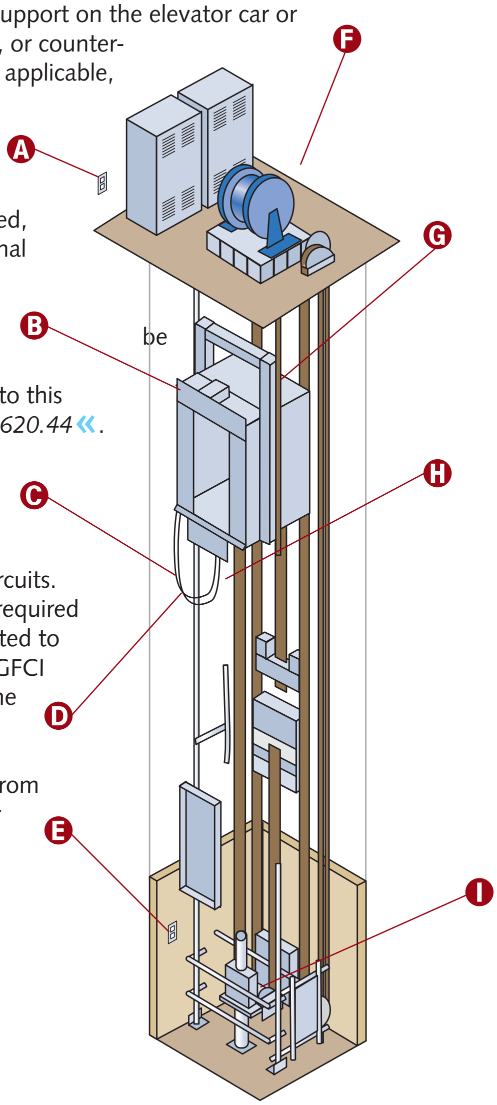
Each 125-volt, single-phase, 15- and 20-ampere receptacle installed in pits or hoistways, on the cars of elevators and dumbwaiters associated with wind turbine tower elevators, on the platforms or in the runways and machinery spaces of platform lifts and stairway chairlifts, and in escalator and moving walk wellways shall be of the Class A GFCI type. All 125-volt, single-phase, 15- and 20-ampere receptacles installed in machine rooms, control spaces, machinery spaces, control rooms, and truss interiors shall have Class A GFCI protection for personnel »*620.6*«.

H Traveling cables that are suitably supported and protected from physical damage shall be permitted to be run without the use of a raceway in either or both of the following:

(1) When used inside the hoistway, on the elevator car, hoistway wall, counterweight, or controllers and machinery that are located inside the hoistway, provided the cables are in the original sheath.

(2) From inside the hoistway, to elevator controller enclosures and to elevator car and machine room, control room, machinery space, and control space connections that are located outside the hoistway for a distance not exceeding 6 ft (1.8 m) in length as measured from the first point of support on the elevator car or hoistway wall, or counterweight where applicable, provided the conductors are grouped together and taped or corded, or in the original sheath. These traveling cables shall be permitted to be continued to this equipment »*620.44*«.

I Hoistway pit lighting and receptacles shall be supplied by separate branch circuits. In no case should required lighting be connected to the load side of a GFCI »*620.24(A)*«. The lighting switch's location shall be readily accessible from the pit access door »*620.24(B)*«.



Note

For electric elevators, all motor frames, elevator machines, controllers, and metal electrical-equipment enclosures in (or on) the car or in the hoistway shall be bonded per Article 250, Parts V and VII »***620.82***«.

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Protection and Control

A single means for disconnecting all ungrounded main power supply conductors for each elevator, dumbwaiter, escalator, moving walk, platform lift, or stairway chairlift shall be provided and be designed so that no pole can be operated independently. Where multiple driving machines are connected to a single elevator, escalator, moving walk, or pumping unit, a single means shall be provided to disconnect the motor(s) and control valve operating magnets »*620.51*«.

The location of the disconnecting means shall be readily accessible to qualified persons »*620.51(C)*«. Depending on the application, the location must comply with 1, 2, 3, or 4 in 620.51(C).

The disconnecting means shall be legibly marked in the field with the available fault current at its line terminals. The field marking(s) shall include the date the available fault current calculation was performed and be of sufficient durability to withstand the environment involved »*620.51(D)(1)*«.

Each elevator car shall have a single means for disconnecting all ungrounded car light, receptacle(s), and ventilation power-supply conductors. The disconnecting means shall be an enclosed externally operable fused motor-circuit switch or circuit breaker that is lockable open in accordance with 110.25 and shall be located in that elevator car's machine/control room. Where there is no machine room or control room, the disconnecting means shall be located in a machinery space or control space outside the hoistway that is readily accessible to only qualified persons. Each disconnecting means shall be numbered to correspond with the identifying number of the car whose light source it controls. The disconnecting means shall have a sign identifying the location of the supply side overcurrent protective device »*620.53*«.

Operating devices and control/signaling circuits shall be protected against overcurrent according to 724.43 and 724.45. Class 2 power-limited circuits shall be protected against overcurrent in accordance with the requirements of Chapter 9, Notes to Tables 11(A) and 11(B) »*620.61(A)*«.

Duty on elevator and dumbwaiter driving machine motors and driving motors of motor generators (used with generator field control) is rated as *intermittent*. Such motors shall be permitted to be protected against overload per 430.33 »*620.61(B)(1)*«.

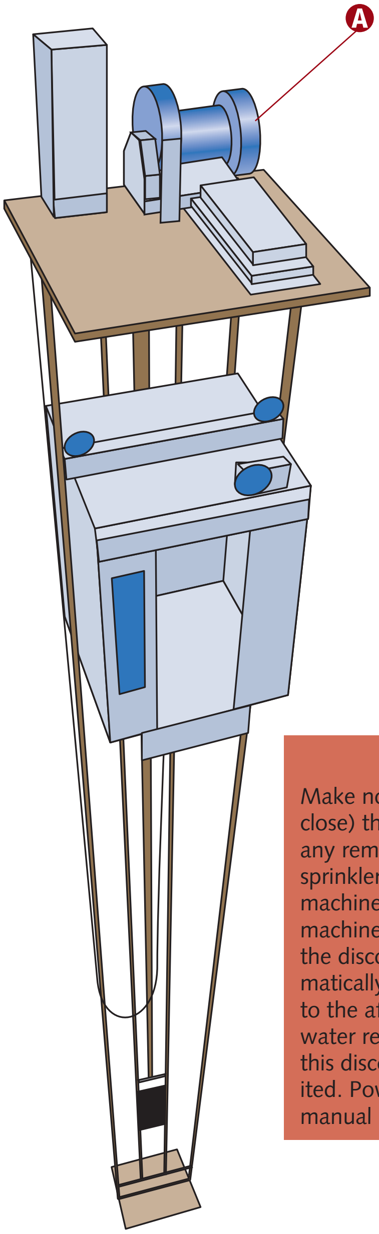
Duty on escalator and moving walk driving machine motors is rated as *continuous*. Protect such motors against overload in accordance with 430.32 »*620.61(B)(2)*«. Escalator and moving walk driving machine motors, and driving motors of motor-generator sets, shall be protected against running overload as provided in Table 430.37 »*620.61(B)(3)*«.

Platform lift and stairway chairlift driving machine motor duty is rated as *intermittent*. Such motors can be protected against overload according to 430.33 »*620.61(B)(4)*«.

A Elevator, dumbwaiter, escalator, and moving walk driving machines; motor-generator sets; motor controllers; and disconnecting means shall be installed in a room or space dedicated for that purpose, unless otherwise permitted in 620.71(A) or (B). The room or enclosure shall be secured against unauthorized access »*620.71*«.

Note

Elevator emergency and standby power systems must comply with 620.91.



Caution

Make no provision to open (or close) the disconnecting means from any remote part of the premises. If sprinklers are installed in hoistways, machine rooms, control rooms, machinery spaces, or control spaces, the disconnecting means can automatically open the power supply to the affected elevator(s) prior to water release. Automatic closure of this disconnecting means is prohibited. Power shall be restored only by manual means »*620.51(B)*«.

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Swimming Pools, Fountains, and Similar Installations

General

All electrical equipment and products covered by Article 680 shall be installed in compliance with Article 680 and shall be listed »*680.6*«.

Grounding and bonding terminals shall be identified for use in wet and corrosive environments. Field-installed grounding and bonding connections in a damp, wet, or corrosive environment shall be composed of copper, copper alloy, or stainless steel. They shall be listed for direct burial use »*680.7(C)*«.

Provisions for storable pools, storable spas, storable hot tubs, and storable immersion pools are located in Article 680, Part III (680.30 through .35).

The provisions of Article 680, Part I and Part VI shall apply to therapeutic pools and tubs in health care facilities, gymnasiums, athletic training rooms, and similar areas »*680.60*«.

Hydromassage bathtub requirements are located in Article 680, Part VII.

Ⓐ Article 680 provisions apply to the electrical wiring construction (and installation) and for equipment in or adjacent to all swimming, wading, therapeutic, and decorative pools, fountains, hot tubs, spas, and hydromassage bathtubs, whether permanently installed or storable, as well as to similar metallic auxiliary equipment (such as pumps, filters, etc.). The term *body of water* used throughout Part I applies to all bodies of water covered in this scope unless otherwise amended »*680.1*«.

Ⓑ **Fountain:** Includes fountains, splash pads, ornamental pools, display pools, and reflection pools, but drinking fountains are not included »*Article 100*«.

Ⓒ Part I and Part V provisions apply to all permanently installed fountains as defined in Article 100. Fountains that have water common to a pool shall also comply with Part II of Article 680. Fountains intended for recreational use by pedestrians, including splash pads, shall additionally comply with the requirements in 680.26.
Part V does not cover self-contained, portable fountains. Portable fountains shall comply with Parts II and III of Article 422 »*680.50*«.

Ⓓ **Permanently installed decorative fountains and reflection pools:** Those that are constructed in or on the ground, or in a building so that the fountain cannot be readily disassembled, with or without electrical circuits of any nature. These units are constructed primarily for their aesthetic value and are not intended for swimming or wading »*Article 100*«.

Ⓔ **Spa or hot tub:** A hydromassage pool or tub for recreational or therapeutic use, not located in health care facilities, designed for immersion of users, and usually having a filter, heater, and motor-driven blower. It may be installed either indoors or out and on or in the ground or supporting structure. Generally, a spa or hot tub is not designed to be drained after each use »*Article 100*«.

Ⓕ Spa and hot tub requirements can be found in Article 680, Part IV (680.40 through 45).

Ⓖ Equipotential bonding provisions for permanently installed pools are located in 680.26.

Ⓗ **Pool:** Manufactured or field-constructed equipment designed to contain water on a permanent or semipermanent basis, and used for swimming, wading, immersion, or therapeutic purposes »*Article 100*«.

Ⓘ Permanently installed pool underwater luminaire requirements are located in 680.23.

Ⓙ **Permanently installed swimming, wading, immersion, and therapeutic pools:** Those that are constructed totally or partially in the ground, and all pools installed inside of a building, whether or not served by electrical circuits of any nature »*Article 100*«.

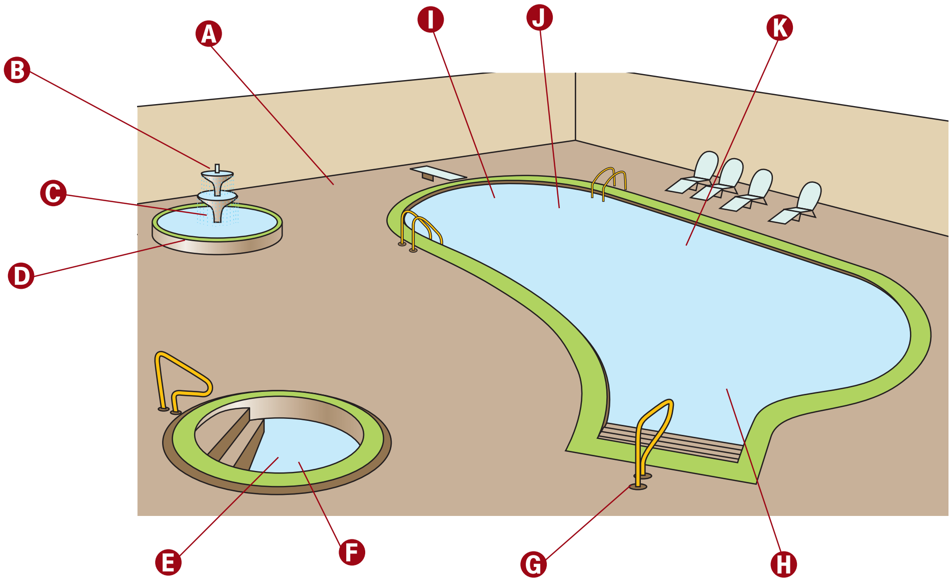
Ⓚ Permanently installed pools must comply with Article 680, Part II.

Note

The AHJ shall be permitted to require periodic inspection and testing for swimming pools, spas, hot tub, fountains, and similar installations ***»680.4«***

Note

Swimming pool overhead conductor clearance requirements are located in 680.9 and Table 680.9(A).



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Definitions

A Self-contained spa or hot tub: Factory-fabricated unit consisting of a spa or hot tub vessel having integrated water-circulating, heating, and control equipment. Equipment may include pumps, air blowers, heaters, lights, controls, sanitizer generators, etc. »*Article 100*«.

B Hydromassage bathtub: A permanently installed bathtub with recirculation piping, pump, and associated equipment. It is designed to accept, circulate, and discharge water at each use »*Article 100*«.

C Wet-niche luminaire: A luminaire intended for installation in a pool or fountain structure's forming shell, where completely surrounded by water »*Article 100*«.

D Storable swimming, wading, or immersion pools: Pools installed entirely on or above the ground that are intended to be stored when not in use and are designed for ease of relocation, regardless of water depth »*Article 100*«.

E Pool cover, electrically operated: Motor-driven equipment designed to cover and uncover the pool's water surface by means of a flexible sheet or rigid frame »*Article 100*«.

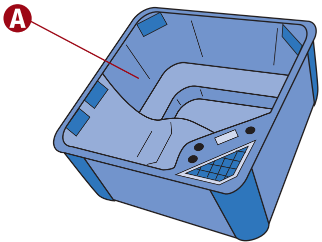
F Cord- and plug-connected lighting assembly: A lighting assembly consisting of a luminaire intended for installation in the wall of a spa, hot tub, or storable pool, having a cord- and plug-connected transformer or power supply »*Article 100*«.

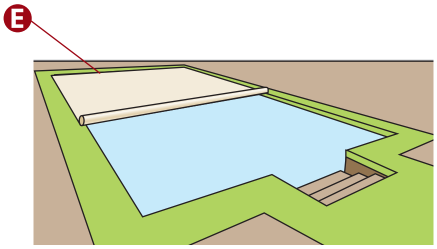
G Forming shell: A support structure designed for a wet-niche luminaire assembly and intended for pool or fountain structure mounting »*Article 100*«.

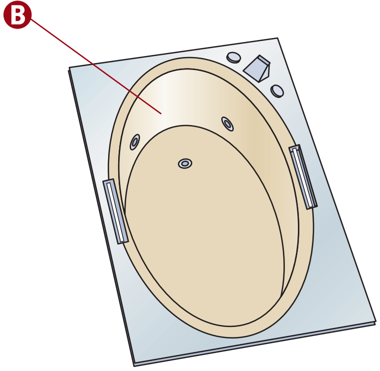
H Packaged spa or hot tub equipment assembly: A factory-fabricated unit consisting of water-circulating, heating, and control equipment mounted on a common base and that operates as a spa or hot tub. Equipment may include pumps, air blowers, heaters, lights, controls, sanitizer generators, etc. »*Article 100*«.

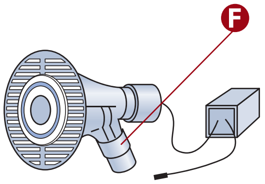
I Self-contained therapeutic tubs or hydrotherapeutic tanks: A factory-fabricated unit consisting of a therapeutic tub or hydrotherapeutic tank with integrated water-circulating, heating, and control equipment. Equipment may include pumps, air blowers, heaters, lights, controls, sanitizer generators, etc. »*Article 100*«.

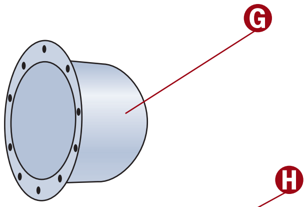
J No-niche luminaire: A luminaire intended for above or below water installation without a niche »*Article 100*«. Note: Not to be mistaken for a dry-niche luminaire.

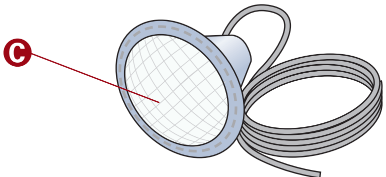


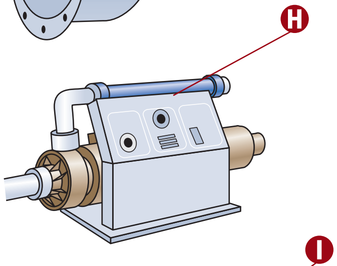


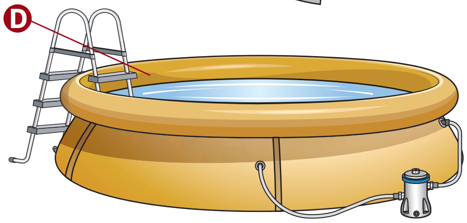


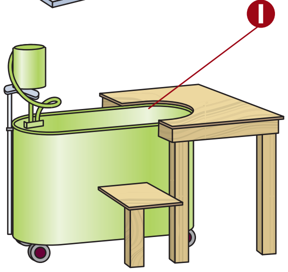


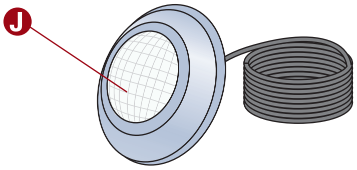












K Dry-niche luminaire: A luminaire intended for installation in the floor or wall of a pool, spa, or fountain in a niche that is sealed against water entry »*Article 100*«.

Note

An electrically powered pool lift is an electrically powered lift that provides accessibility for people with disabilities to and from a pool or spa »***Article 100***«.

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Conductive Pool Shells and Perimeter Surfaces

The equipotential bonding required by 680.26(B) and (C) shall be installed to reduce voltage gradients in the pool area for pools with or without associated electrical equipment related to the pool »*680.26(A)*«.

Ⓐ The parts specified in 680.26(B)(1) through (B)(7) shall be bonded together using solid copper conductors, insulated covered, or bare, not smaller than 8 AWG or with rigid metal conduit of brass or other identified corrosion-resistant metal. Connections to bonded parts shall be made in accordance with 250.8. An 8 AWG or larger solid copper bonding conductor provided to reduce voltage gradients in the pool area shall not be required to be extended or attached to remote panelboards, service equipment, or electrodes »*680.26(B)*«.

Ⓑ Bonding to conductive pool shells shall be provided as specified in 680.26(B)(1)(a) or 680.26(B)(1)(b). Cast-in-place concrete, pneumatically applied or sprayed concrete, and concrete block with painted or plastered coatings shall all be considered conductive materials due to water permeability and porosity. Vinyl liners and fiberglass composite shells shall be considered to be nonconductive materials and not subject to the requirements of this section. Reconstructed pool shells shall also meet the requirements of this section.»*680.26(B)(1)*«.

Ⓒ Unencapsulated structural reinforcing steel shall be bonded together by steel tie wires or the equivalent. Where structural reinforcing steel is encapsulated in a nonconductive compound, a copper conductor grid shall be installed in accordance with 680.26(B)(1)(b) »*680.26(B)(1)(a)*«. A copper conductor grid shall be provided and shall: (1) be constructed of minimum 8 AWG bare solid copper conductors bonded to each other at all points of crossing (the bonding shall be in accordance with 250.8 or other approved means), (2) conform to the contour of the pool, (3) be arranged in a 12-in. × 12-in. (300-mm × 300-mm) network of conductors in a uniformly spaced perpendicular grid pattern with a tolerance of 4 in. (100 mm), and (4) be secured within or under the pool no more than 6 in. (150 mm) from the outer contour of the pool shell »*680.26(B)(1)(b)*«.

Ⓓ The perimeter surface to be bonded shall be considered to extend for 3 ft (1 m) horizontally beyond the inside walls of the pool and shall include unpaved surfaces and other types of paving. Perimeter surfaces separated by a permanent wall or building 5 ft (1.5 m) in height or more shall require equipotential bonding only on the pool side of the permanent wall or building. Bonding to perimeter surfaces shall be provided as specified in 680.26(B)(2)(a), 680.26(B)(2)(b) or 680.26(B)(2)(c) and shall be attached to the pool reinforcing steel or copper conductor grid at a minimum of four (4) points uniformly spaced around the perimeter of the pool. For nonconductive pool shells, bonding at four points shall not be required »*680.26(B)(2)*«.

(a) Structural reinforcing steel shall be bonded in accordance with 680.26(B)(1)(a).

(b) Where structural reinforcing steel is not available or is encapsulated in a nonconductive compound, a copper conductor(s) shall be utilized where the following requirements are met:

  (1) At least one minimum 8 AWG bare solid copper conductor shall be provided.

  (2) The conductors shall follow the contour of the perimeter surface.

  (3) Only listed splicing devices or exothermic welding shall be permitted.

  (4) The required conductor shall be 18 to 24 in. (450 to 600 mm) from the inside walls of the pool.

  (5) The required conductor shall be secured within or under the perimeter surface 4 to 6 in. (100 to 150 mm) below the subgrade.

(c) Where structural reinforcing steel is not available or is encapsulated in a nonconductive compound, copper grid shall be utilized where the following requirements are met:

  (1) The copper grid shall be constructed of 8-AWG solid bare copper and be arranged in accordance with 680.26(B)(1)(b)(3).

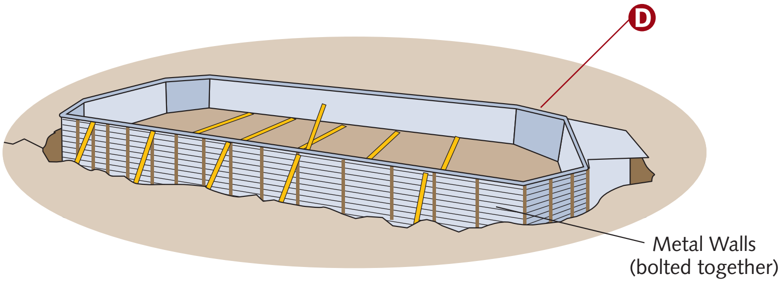
  (2) The copper grid shall follow the contour of the perimeter surface extending 3 ft (1 m) horizontally beyond the inside walls of the pool.

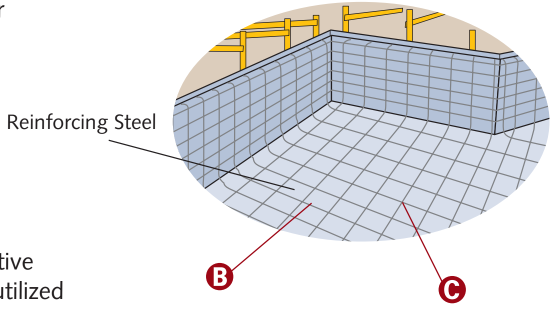
  (3) Only listed splicing devices or exothermic welding shall be permitted.

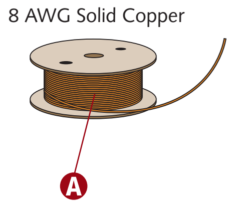
  (4) The copper grid shall be secured within or under the deck or unpaved surfaces between 4 in. to 6 in. (100 mm to 150 mm) below the subgrade »*680.26(B)(2)(a), (b), and (c)*«.

Note

All metallic parts of the pool structure, including reinforcing metal not addressed in 680.26(B)(1)(a), shall be bonded. Where reinforcing steel is encapsulated with a nonconductive compound, the reinforcing steel shall not be required to be bonded **»*680.26(B)(3)*«**.







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Receptacles

A Other receptacles shall be not less than 6 ft (1.83 m) from the inside walls of a pool »*680.22(A)(3)*«.

B Receptacles that provide power for water-pump motors or for other loads directly related to the circulation and sanitation system shall be located at least 6 ft (1.83 m) from the inside walls of the pool. These receptacles shall have GFCI protection and be of the grounding type »*680.22(A)(2)*«.

C Where a permanently installed pool is installed, no fewer than one 125-volt 15- or 20-ampere receptacle on a general-purpose branch circuit shall be located a minimum of 6 ft (1.83 m), but no more than 20 ft (6.0 m), from the pool's inside wall. This receptacle shall not be more than 6 ft, 6 in. (2.0 m) above the floor, platform, or grade level serving the pool »*680.22(A)(1)*«.

Note

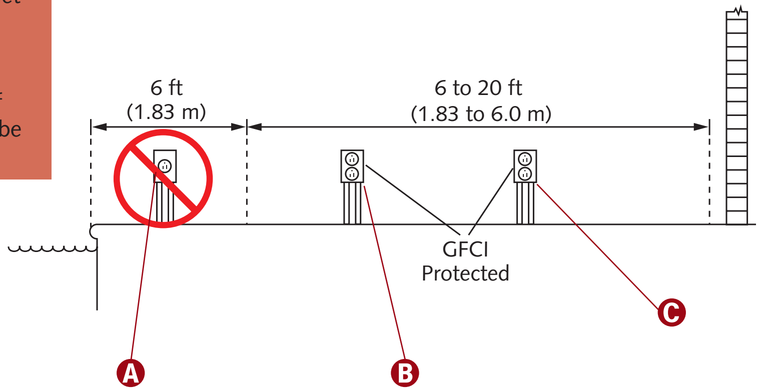
Where required in Article 680, ground-fault protection of receptacles and outlets on branch circuits operating at voltages above 150 volts to ground, not exceeding 480 volts phase-to-phase, single- or 3-phase, shall be provided with SPGFCI (special purpose ground-fault circuit-interrupter) protection not to exceed 20-mA ground-fault trip current ***»680.5(C)«***.

Caution

Fifteen- and 20-ampere, 125- and 250-volt receptacles installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed, and shall be identified as "extra-duty." All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles shall be listed weather-resistant type. Hinged covers of outlet box hoods shall be able to open at least 90 degrees or fully open if the cover is not designed to open 90 degrees from the closed to open position after installation. Other listed products, enclosures, or assemblies providing weatherproof protection that do not utilize an outlet box hood need not be identified extra duty »*406.9(B)(1)*«.

Note

All receptacles rated 125 volts through 250 volts, 60 amperes or less, located within 20 ft (6.0 m) of the inside walls of a pool shall have GFCI protection complying with 680.5(B) or SPGFCI protection complying with 680.5(C) as applicable ***»680.22(A)(4)«***. This distance is determined by measuring the shortest path that the appliance supply cord (connected to the receptacle) would follow without piercing a floor, wall, ceiling, hinged or sliding panel doorway, window opening, or other effective permanent barrier ***»680.22(A)(5)«***.



Equipotential Bonding

The parts specified in 680.26(B)(1) through (B)(7) shall be bonded together using solid copper conductors, insulated, covered, or bare, not smaller than 8 AWG or with rigid metal conduit of brass or other identified corrosion-resistant metal. Connections to bonded parts shall be made in accordance with 250.8. An 8 AWG or larger solid copper bonding conductor provided to reduce voltage gradients in the pool area shall not be required to be extended or attached to remote panelboards, service equipment, or electrodes »*680.26(B)*«.

All metallic parts of the pool structure, including reinforcing metal not addressed in 680.26(B)(1)(a), shall be bonded »*680.26(B)(3)*«.

A All fixed metal parts shall be bonded including, but not limited to, metal-sheathed cables and raceways, metal piping, metal awnings, metal fences, and metal door and window frames »*680.26(B)(7)*«. Fixed metal parts that are not required to be bonded include: (1) those separated from the pool by a permanent barrier that prevents contact by a person, (2) those greater than 5 ft (1.5 m) horizontally from the inside walls of the pool, and (3) those greater than 12 ft (3.7 m) measured vertically above the pool's maximum water level, or as measured vertically above any observation stands, towers, or platforms, or any diving structures »*680.26(B)(7)* and *Exception*«.

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Equipotential Bonding *(continued)*

Ⓑ Bond all metal forming shells and mounting brackets of no-niche luminaires, unless using a listed low-voltage lighting system with a nonmetallic forming shell *»680.26(B)(4)«*.

Ⓒ Bond any diving structure, observation stands, towers, or platforms unless one of the exceptions in 680.26(B)(7) is met *»680.26(B)(7)«*.

Ⓓ Bond all metal fittings within or attached to the pool structure *»680.26(B)(5)«*.

Ⓔ Isolated parts not more than 4 in. (100 mm) in any dimension that do not penetrate the pool's structure more than 1 in. (25 mm) do not require bonding *»680.26(B)(5) Exception«*.

Ⓕ Bonding to conductive pool shells shall be provided as specified in 680.26(B)(1)(a) or 680.26(B)(1)(b) *»680.26(B)(1)«*. (See section in this text titled "Conductive Pool Shells and Perimeter Surfaces.")

Ⓖ Bond all metal fittings within or attached to the pool structure *»680.26(B)(5)«*.

Ⓗ Bond all metal parts of equipment associated with pool covers, including electric motors, heaters, pool covers, and so on *»680.26(B)(6)«*.

Ⓘ Bond metal parts of electrical equipment associated with the pool water circulating system, including pump motors. (Metal parts of listed equipment incorporating an approved system of double insulation shall not be bonded) *»680.26(B)(6)«*. Note: Pool electrical equipment must be bonded to the equipotential bonding grid regardless of the intervening distance or location to the pool.

Ⓙ Where reinforcing steel is encapsulated with a nonconductive compound, the reinforcing steel shall not be required to be bonded *»680.26(B)(3)«*.

Ⓚ Unencapsulated structural reinforcing steel shall be bonded together by steel tie wires or the equivalent *»680.26(B)(1)(a)«*.

Ⓛ Bonding to perimeter surfaces shall be provided as specified in 680.26(B)(2)(a), 680.26(B)(2)(b), or 680.26(B)(2)(c) and shall be attached to the pool reinforcing steel or copper conductor grid at a minimum of four (4) points uniformly spaced around the perimeter of the pool. The perimeter surface to be bonded shall be considered to extend for 3 ft (1 m) horizontally beyond the inside walls of the pool and shall include unpaved surfaces as well as poured concrete surfaces and other types of paving. Perimeter surfaces less than 3 ft (1 m) separated by a permanent wall or building 5 ft (1.5 m) in height or more shall require equipotential bonding only on the pool side of the permanent wall or building *»680.26(B)(2)«*.

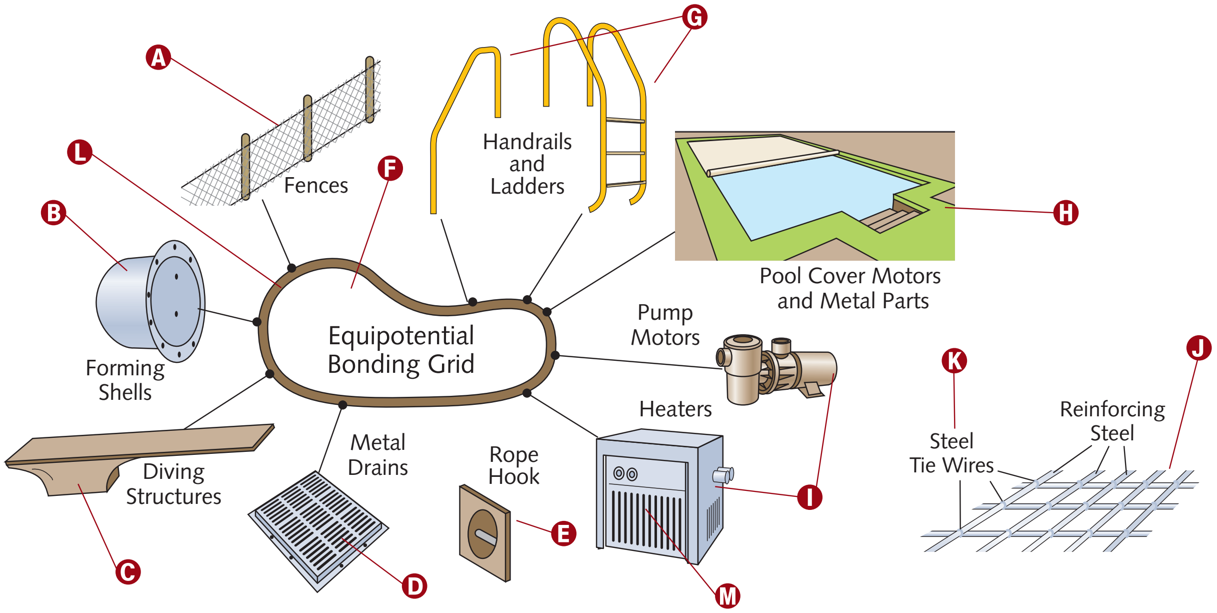
Ⓜ For pool water heaters rated at more than 50 amperes and having specific instructions regarding bonding and grounding, only those parts designated to be bonded shall be bonded and only those parts designated to be grounded shall be grounded *»680.26(B)(6)(b)«*.

Warning

Where none of the bonded parts is in direct connection with the pool water, the pool water shall be in direct contact with an approved corrosion-resistant conductive surface that exposes not less than 9 in.^{2} (5800 mm^2) of surface area to the pool water at all times. The conductive surface shall be located where it is not exposed to physical damage or dislodgement during usual pool activities, and it shall be bonded in accordance with 680.26(B) *»680.26(C)«*.

Note

Where a double insulated pump motor is installed, under the provisions of 680.26(A)(6) Exception, a solid 8-AWG copper conductor of sufficient length to make a bonding connection to a replacement motor shall be extended from the swimming pool equipotential bonding means to an accessible point in the vicinity of the pool pump motor ***»680.26(A)(6)(a)«***.



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Luminaires, Lighting Outlets, and Ceiling-Suspended (Paddle) Fans

For installations in indoor pool areas, the clearances shall be the same as for outdoor areas unless modified as provided in this paragraph. If the branch circuit supplying the equipment is protected by a GFCI, the following equipment shall be permitted at a height not less than 7 ft 6 in. (2.3 m) above the maximum pool water level: (1) totally enclosed luminaires; and (2) ceiling-suspended (paddle) fans identified for use beneath ceiling structures such as provided on porches or patios »*680.22(B)(2)*«.

Cord- and plug-connected luminaires shall meet the same 680.8 specifications, where installed within 16 ft (4.9 m) of any point along the water's surface, measured radially »*680.22(B)(5)*«.

The provisions of 680.27(C) shall apply to all pool deck areas, including a covered pool, where electrically operated comfort heating units are installed within 20 ft (6.0 m) of the inside wall of the pool.

(1) Unit heaters: Unit heaters shall be rigidly mounted to the structure and shall be of the totally enclosed or guarded type. Unit heaters shall not be mounted over the pool or within the area extending 5 ft (1.5 m) horizontally from the inside walls of a pool.

(2) Permanently wired radiant heaters: Radiant electric heaters shall be suitably guarded and securely fastened to their mounting device(s). Heaters shall not be installed over a pool or within the area extending 5 ft (1.5 m) horizontally from the inside walls of the pool and shall be mounted at least 12 ft (3.7 m) vertically above the pool deck unless otherwise approved.

(3) Radiant heating cables not permitted: Radiant heating cables embedded in or below the deck shall not be permitted »*680.27(C)*«.

A For new installations in outdoor pool areas, luminaires, lighting outlets, and ceiling-suspended (paddle) fans shall not be installed over the pool, or over the area extending 5 ft (1.5 m) horizontally from the pool's inside walls, unless located not less than 12 ft (3.7 m) above the maximum water level »*680.22(B)(1)*«.

B Existing luminaires and lighting outlets located less than 5 ft (1.5 m), measured horizontally from the pool's inside walls, shall be (1) at least 5 ft (1.5 m) above the maximum water level surface; (2) rigidly attached to the existing structure; and (3) protected by a GFCI »*680.22(B)(3)*«.

C Luminaires and lighting outlets, and ceiling-suspended (paddle) fans installed in the area extending between 5 ft (1.5 m) and 10 ft (3.0 m) horizontally from a pool's inside walls shall be protected by a GFCI or SPGFCI, unless 5 ft (1.5 m) above the maximum water level and rigidly attached to the pool's adjacent (or enclosing) structure »*680.22(B)(4)*«.

D Listed low-voltage luminaires not requiring grounding, not exceeding the low-voltage contact limit, and supplied by listed transformers or power supplies that comply with 680.23(A)(2) shall be permitted to be located less than 5 ft (1.5 m) from the inside walls of the pool »*680.22(B)(6)*«.

Note

Locate all switching devices on the property at least 5 ft (1.5 m) horizontally from a pool's inside walls, unless separated from the pool by a solid fence, wall, or other permanent barrier that provides at least a 5 ft (1.5 m) reach distance. A switch listed as being acceptable for use within 5 ft (1.5 m) is also permitted »***680.22(C)***«.

Note

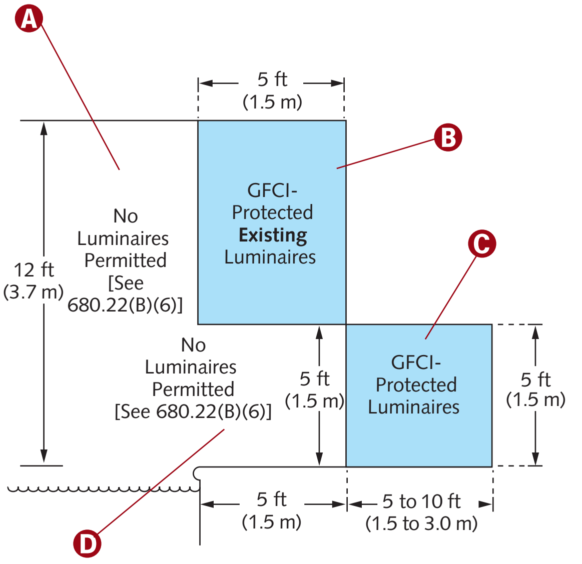
In determining the dimensions in this section addressing luminaires, the distance to be measured shall be the shortest path an imaginary cord connected to the luminaire would follow without piercing a floor, wall, ceiling, doorway with hinged or sliding door, window opening, or other effective permanent barrier »***680.22(B)(8)***«.

Note

Listed low-voltage gas-fired-luminaires, decorative fireplaces, fire pits, and similar equipment using low-voltage ignitors that do not require grounding, and are supplied by listed transformers or power supplies that comply with 680.23(A)(2) with outputs that do not exceed the low-voltage contact limit shall be permitted to be located less than 5 ft (1.5 m) from the inside walls of the pool. Metallic equipment shall be bonded in accordance with the requirements in 680.26(B). Transformers or power supplies supplying this type of equipment shall be installed in accordance with the requirements in 680.24. Metallic gas piping shall be bonded in accordance with the requirements in 250.104(B) and 680.26(B)(7) »***680.22(B)(7)***«.

Caution

Other outlets shall be not less than 10 ft (3.0 m) from the inside walls of the pool. Measurements shall be determined in accordance with 680.22(A)(5) »*680.22(D)*«. Other outlets may include, but are not limited to, remote-control, signaling, fire alarm, and communications circuits »*680.22(D) Informational Note*«.



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Underwater Luminaires (Permanently Installed Pools)

Requirements for luminaires installed below the pool's normal water level are covered in 680.23(A) through (F).

Wet-niche luminaire requirements are covered in 680.23(B)(1) through (6).

The grounding terminals of a junction box or transformer/other enclosure in the supply circuit to a wet-niche or no-niche luminaire and the field-wiring chamber of a dry-niche luminaire shall be connected to the panelboard's equipment grounding terminal. This terminal shall be directly connected to the panelboard enclosure »*680.24 (F)*«.

A Luminaires mounted in walls shall be installed so that the top of the luminaire lens is at least 18 in. (450 mm) below the pool's normal water level, unless the luminaire is listed and identified for use at a depth of not less than 4 in. (100 mm) below the pool's normal water level »*680.23(A)(5)*«.

B The 8 AWG bonding conductor termination in the forming shell shall be covered or encapsulated in a listed potting compound to protect it from the possibly deteriorating effect of pool water »*680.23(B)(2)(b)*«.

C The luminaire shall be bonded and secured to the forming shell by a positive locking device that ensures a low-resistance contact, and which can only be removed from the forming shell by use of a tool. Luminaires listed for the application and having no non-current-carrying metal parts do not require bonding »*680.23(B)(5)*«.

Note

Conductors on the load side of a GFCI or transformer, used to comply with 680.23(A)(8) provisions, shall not occupy raceways, boxes, or enclosures containing other conductors, unless one of the following conditions applies:
(1) The other conductors are protected by ground-fault circuit interrupters.
(2) The other conductors are equipment grounding conductors and bonding jumpers as required per 680.23(B)(2)(b).
(3) The other conductors are supply conductors to a feed-through-type GFCI.
(4) Ground-fault circuit interrupters shall be permitted in a panelboard that contains circuits protected by other than ground-fault circuit interrupters »***680.23(F)(3)***«.

Caution

All wet-niche luminaires shall be removable from the water for inspection, relamping, or other maintenance. The forming shell location and length of cord in the forming shell shall permit personnel to place the removed luminaire on the deck or other dry location for such maintenance. The luminaire maintenance location shall be accessible without entering or going in the pool water »*680.23(B)(6)*«.

D Other than listed low-voltage luminaires not requiring grounding, all through-wall lighting assemblies, wet-niche, dry-niche, or no-niche luminaires shall be connected to an insulated 12 AWG or larger equipment grounding conductor sized per Table 250.122 »*680.23(F)(2)*«.

E All metal forming shells shall be bonded to the equipotential bonding grid with a solid copper conductor (insulated, covered, or bare) no smaller than 8 AWG »*680.26(B)(4)*«.

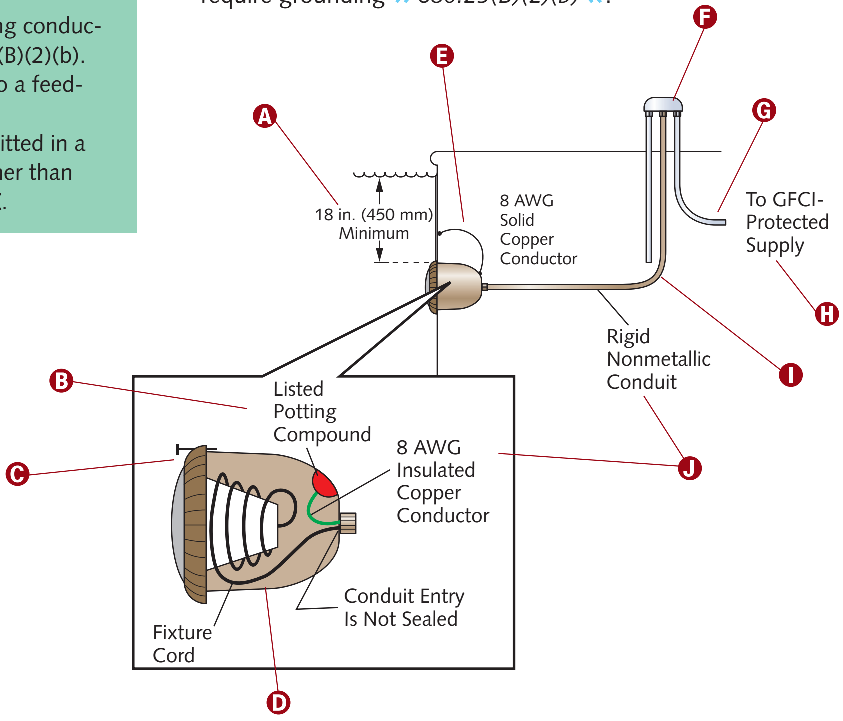
F A junction box connected to a conduit extending directly to a forming shell or mounting bracket of a no-niche luminaire must comply with 680.24(A)(1) and (2).

G The equipment grounding conductor shall be (1) an insulated copper conductor and (2) installed along with the circuit conductors »*680.23(F)(2)*«.

H Ground-fault circuit-interrupter protection for personnel shall be installed in the branch circuit supplying luminaires operating at voltages greater than the low-voltage contact limit »*680.23(A)(3)*«. **Low voltage contact limit** is defined as a voltage not exceeding the following values: (1) 15 volts (RMS) for sinusoidal ac, (2) 21.2 volts peak for nonsinusoidal ac, (3) 30 volts for continuous dc, and (4) 12.4 volts peak for dc that is interrupted at a rate of 10 to 200 Hz »*Article 100*«.

I Conduit shall extend from the forming shell to a junction box (or other enclosure) conforming to the requirements as provided in 680.24. Conduit must be RMC, IMC, LFNC, or PVC. Metal conduit shall be listed and shall be red brass or stainless steel »*680.23(B)(2)* and *(B)(2)(a)*«.

J When using nonmetallic conduit, an 8 AWG insulated copper bonding jumper (solid or stranded) shall be installed in the conduit with provisions for terminating in the forming shell, junction box/transformer enclosure, or GFCI enclosure, unless using a listed low-voltage lighting system that does not require grounding »*680.23(B)(2)(b)*«.


F
E
A
G
18 in. (450 mm) Minimum
8 AWG Solid Copper Conductor
To GFCI-Protected Supply
H
Rigid Nonmetallic Conduit
I
B
Listed Potting Compound
C
8 AWG Insulated Copper Conductor
J
Conduit Entry Is Not Sealed
Fixture Cord
D

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Junction Boxes for Underwater Lighting

A junction box connected to a conduit that extends directly to a forming shell or mounting bracket of a no-niche luminaire shall meet the requirements of 680.24(A) through (F).

An enclosure for a transformer, GFCI, or a similar device connected to a conduit extending directly to a forming shell or mounting bracket of a no-niche luminaire must comply with 680.24(B) requirements.

Junction boxes, transformer and power-supply enclosures, and GFCI enclosures connected to a conduit extending directly to a forming shell or mounting bracket of a no-niche luminaire shall have a number of grounding terminals that exceeds the number of conduit entries by at least one »*680.24(D)*«.

Strain relief shall be provided for the termination of an underwater luminaire's flexible cord within a junction box, transformer enclosure, GFCI, or other enclosure »*680.24(E)*«.

Note

Where branch-circuit wiring on the supply side of enclosures and junction boxes connected to conduits run to underwater luminaires is installed in corrosive environments the wiring method of that portion of the branch circuit shall be in accordance with 680.14 »***680.23(F)(1)***«. Where connecting to transformers or power supplies for pool lights, liquidtight flexible metal conduit shall be permitted. The length shall not exceed 6 ft (1.8 m) for any one length or exceed 10 ft (3.0 m) in total length used »***680.23(F)(1) Exception***«. 680.14(A) allows RMC, IMC, PVC, RTRC, and LFNC to be used in corrosive environments associated with swimming pools. Aluminum conduit and tubing are not permitted.

Ⓐ Locate the junction box at least 4 ft (1.2 m) from the pool's inside wall, unless separated from the pool by a solid fence, wall, or other permanent barrier »*680.24(A)(2)(b)*«.

Ⓑ A junction box connected to a conduit extending directly to a forming shell or mounting bracket of a no-niche luminaire must comply with 680.24(A)(1)(1) through (3).

Ⓒ The junction box shall be listed, labeled, and identified as a swimming pool junction box »*680.24(A)(1)*«.

Ⓓ The junction box shall be comprised of copper, brass, suitable plastic, or other approved corrosion-resistant material »*680.24(A)(1)(2)*«.

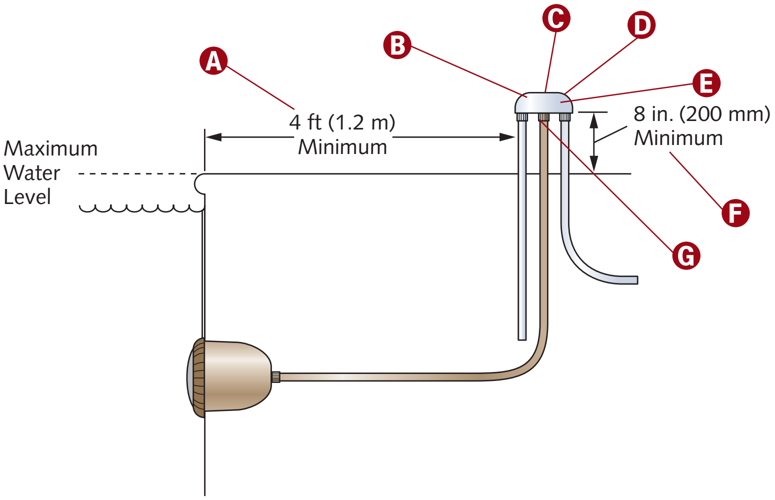
Ⓔ The junction box shall have electrical continuity (between every connected metal conduit and the grounding terminals) by means of copper, brass, or other approved corrosion-resistant metal that is integral with the box »*680.24(A)(1)(3)*«.

Ⓕ Measured from the inside of the bottom of the box, the junction box shall be located at least 8 in. (200 mm) above the maximum pool water level »*680.24(A)(2)(a)*«. [Note: The bottom of the junction box must not be less than 4 in. [100 mm] above the ground level or pool deck.]

Ⓖ The junction box shall be equipped with threaded entries/hubs or a nonmetallic hub »*680.24(A)(1)(1)*«.

Caution

Junction boxes and enclosures mounted above the grade of the finished walkway around the pool shall not be located in the walkway unless afforded additional protection, such as by location under diving boards, adjacent to fixed structures, and the like »*680.24(C)*«.



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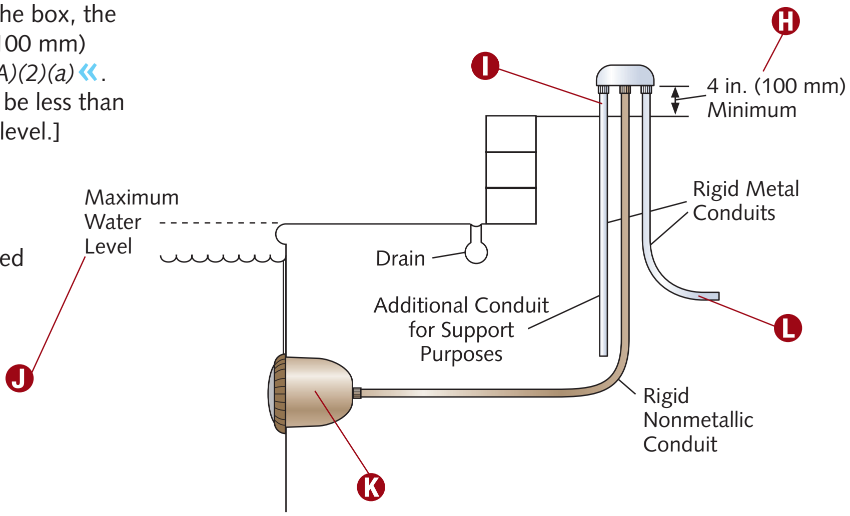
Junction Boxes for Underwater Lighting *(continued)*

Ⓗ Measured from the inside of the bottom of the box, the junction box shall be located no less than 4 in. (100 mm) above the ground level, or pool deck »*680.24(A)(2)(a)*«. [Note: The bottom of the junction box must not be less than 8 in. [200 mm] above the maximum pool water level.]

Ⓘ A swimming pool junction box must comply with 314.23(E) support provisions. It must be supported by *two* or more conduits (rigid or intermediate metal conduit only) threaded wrenchtight into the enclosure or hubs. Secure each conduit within 18 in. (450 mm) of the enclosure since all entries are on the same side. Note: PVC is not permitted for swimming pool junction box support.

Ⓙ **Maximum water level** is defined as the highest level that water can reach before it spills out »*Article 100*«.

Ⓚ Forming shells shall be installed for the mounting of all wet-niche underwater luminaires and shall be equipped with provisions for conduit entries. Metal parts of the luminaire and forming shell in contact with the pool water shall be of brass or other approved corrosion-resistant metal. All forming shells used with nonmetallic conduit systems, other than those that are part of a listed low-voltage lighting system not requiring grounding, shall include provisions for terminating an 8 AWG copper conductor »*680.23(B)(1)*«.



Ⓛ The grounding terminals of a junction box, transformer enclosure, or other enclosure in the supply circuit to a wet-niche or no-niche luminaire and the field-wiring chamber of a dry-niche luminaire shall be connected to the equipment grounding terminal of the panelboard. This terminal shall be directly connected to the panelboard enclosure »*680.24(F)*«.

Equipment and Feeders

Feeders and branch circuits installed in a corrosive environment or wet location shall contain an equipment grounding conductor that is an insulated copper conductor sized in accordance with Table 250.122, but not smaller than 12 AWG. Flexible cords shall contain an equipment grounding conductor that is an insulated copper conductor sized in accordance with Table 250.122, but not smaller than 12 AWG. The flexible cord shall terminate in a grounding-type plug having a fixed grounding contact member. Terminals used for bonding and equipment grounding shall be identified for use in wet locations. Field-installed terminals in damp or wet locations or corrosive environments shall be composed of copper, copper alloy, or stainless steel and shall be listed for direct burial use »*680.7(A), (B), and (C)*«.

Pool-associated motors shall be permitted to employ cord-and-plug connections. The flexible cord shall not exceed 3 ft (900 mm) in length. »*680.21(A)(2)*«.

Aluminum conduit and tubing shall not be permitted in the pool area where subject to corrosion »*680.14(A)*«.

Electric equipment shall not be installed in rooms (or pits) that do not have drainage that prevents water accumulation during normal operation or maintenance unless the equipment is rated and identified for submersion »*680.12(A)*«. Chemicals such as chlorine cause severe corrosive and deteriorating effects on electrical connections, equipment, and enclosures when stored and kept in the same vicinity »*680.12(A) Informational Note*«.

A permanently installed pool can have listed cord- and plug-connected pool pumps that incorporate an approved double insulation system and provide a grounding means for the pump's internal and inaccessible, non-current-carrying metal parts. This listed cord- and plug-connected pool pump shall be connected to any wiring method recognized in Chapter 3 that is suitable for the location. Where the bonding grid is connected to the equipment grounding conductor of the motor circuit in accordance with the second sentence of 680.26(B)(6)(a), the branch-circuit wiring shall comply with 680.21(A) »*680.21(B)*«.

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Equipment and Feeders *(continued)*

A Wiring methods shall be suitable for corrosive environments. RMC, IMC, PVC, RTRC, or LFNC shall be used. Aluminum conduit and tubing shall not be permitted »*680.14(A)*«. Wiring methods installed in these locations shall contain an insulated copper equipment grounding conductor sized in accordance with Table 250.122 but not smaller than 12 AWG. »*680.7(A)*«.

B One or more means to simultaneously disconnect all ungrounded conductors shall be provided for all utilization equipment other than lighting. Each means shall be readily accessible and within sight from its equipment and shall be located at least 5 ft (1.5 m) horizontally from the inside walls of a pool, spa, fountain, or hot tub unless separated from the open water by a permanently installed barrier that provides a 5-ft (1.5-m) reach path or greater. This horizontal distance is to be measured from the water's edge along the shortest path required to reach the disconnect »*680.13*«.

C The wiring to a pool motor shall comply with 680.21(A)(1) or (A)(2).

(A)(1) Where flexible connections are necessary at or adjacent to the motor, liquidtight flexible nonmetallic conduit or MC cable suitable for the use shall be permitted.

(A)(2) Pool-associated motors shall be permitted to be cord-and-plug connected if the flexible cord does not exceed 3 ft (900 mm) in length. »*680.21(A)*«.

D Where connections must be flexible at (or adjacent to) the motor, LFMC, LFNC, or MC cable suitable for the use shall be permitted »*680.21(A)(2)*«.

Warning

Where GFCI protection is required, by Article 680, for receptacles and outlets on branch circuits rated 150 volts or less to ground and 60 amperes or less, single- or 3-phase, Class A GFCI protection shall be provided »*680.5(B)*«.

Caution

Grounding and bonding terminals shall be identified for use in wet and corrosive environments. Field-installed grounding and bonding connections in a damp, wet, or corrosive environment shall be composed of copper, copper alloy, or stainless steel. They shall be listed for direct burial use »*680.7(C)*«.

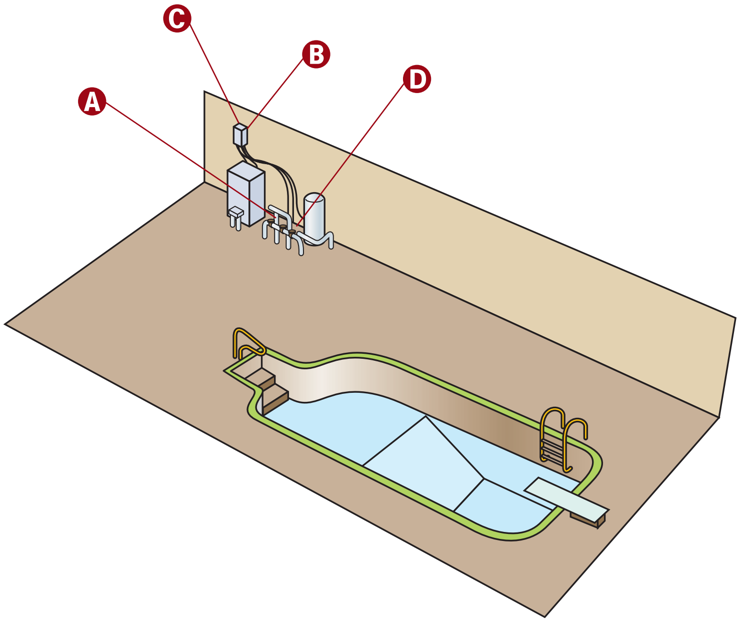
Note

Underground wiring shall be permitted within 5 ft (1.5 m) horizontally from the inside wall of the pool where installed in rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit, reinforced thermosetting resin conduit, jacketed MC cable that is listed for burial use, LFNC listed for direct burial use, or LFMC listed for direct burial use. All wiring methods located within 5 ft (1.5 m) horizontally from the inside wall of the pool shall be installed complete between outlets, junctions, or splicing points. Underground wiring shall not be permitted under the pool unless this wiring is necessary to supply pool equipment permitted by this article »***680.11(A)* and *(B)***«. See Table 300.5(A) for minimum cover requirements.

Note

Areas or enclosures without adequate ventilation, where electrical equipment is located and pool sanitation chemicals are stored, handled, or dispensed are defined as corrosive environments »***Article 100***«.

Adequate ventilation of indoor spaces such as equipment and chemical storage rooms can reduce the likelihood of the accumulation of corrosive vapors. Chemicals such as chlorine cause severe corrosive and deteriorating effects on electrical connections, equipment, and enclosures when stored and kept in the same vicinity »***Informational Note No. 2 under the definition of corrosive environment***«.



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Storable Pools, Storable Spas, and Storable Hot Tubs

A luminaire, operating within the low-voltage contact limit, installed in or on a storable pool's, storable spa's, or storable hot tub's wall shall be part of a cord- and plug-connected lighting assembly. This assembly shall be listed as an assembly for the purpose, and have the following construction features:

1. **No exposed metal parts**
2. **A luminaire lamp that is suitable for use at the supplied voltage**
3. **An impact-resistant polymeric lens, luminaire body, and transformer enclosure**
4. **A transformer or power supply meeting 680.23(A)(2) requirements with a primary rating not over 150 volts »*680.33(A)*«**

A lighting assembly (without a transformer or power supply) whose luminaire lamp(s) operate over the low-voltage contact limit but not over 150 volts, can be cord- and plug-connected where the assembly is listed as an assembly for the purpose. The installation shall comply with 680.23(A)(5), and the assembly shall have the following construction features:

1. **No exposed metal parts**
2. **An impact-resistant polymeric lens and luminaire body**
3. **A GFCI with open neutral conductor protection as an integral part of the assembly**
4. **A permanent connection to the GFCI with open-neutral protection**
5. **Compliance with 680.23(A) requirements »*680.33(B)*«**

Ⓐ Storable swimming, wading, or immersion pool; or storable/portable spas and hot tubs: Pools (or spas) installed entirely on or above the ground that are intended to be stored when not in use and are designed for ease of relocation regardless of water depth »*Article 100*«.

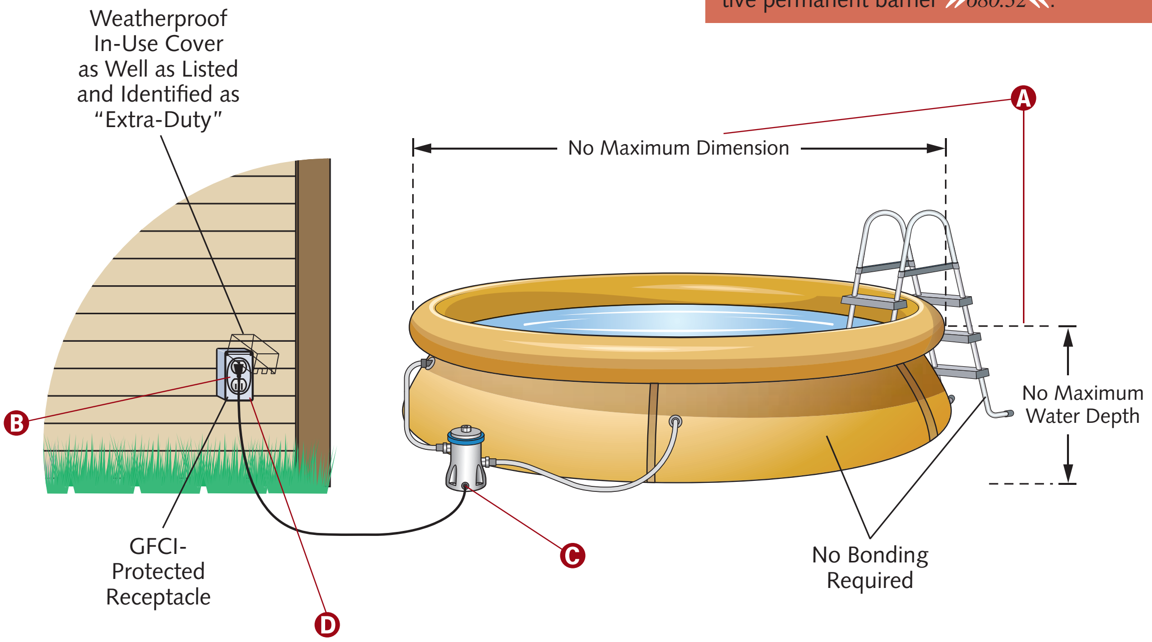
Ⓑ All 15- and 20-ampere, 125- and 250-volt receptacles installed in a wet location shall have an enclosure that is weatherproof whether or not the attachment plug cap is inserted. An outlet box hood installed for this purpose shall be listed and shall be identified as "extra-duty." All 15- and 20-ampere, 125- and 250-volt nonlocking-type receptacles shall be listed weather-resistant type »*406.9(B)(1)*«.

Ⓒ A cord-connected pool filter pump shall incorporate an approved system of double insulation or its equivalent and shall be provided with means for grounding only the internal and nonaccessible non-current-carrying metal parts of the pump. The flexible cord shall have a copper equipment grounding conductor sized in accordance with Table 250.122 but not smaller than 12 AWG that is properly terminated in a grounding-type attachment plug having a fixed grounding contact member. Cord-connected pool filter pumps shall be provided with a GFCI that is an integral part of the attachment plug or located in the power-supply cord within 12 in. (300 mm) of the attachment plug »*680.8(B)* and *680.31*«.

Ⓓ Receptacles shall not be located less than 6 ft (1.83 m) from the inside walls of a storable pool, storable spa, or storable hot tub. In determining these dimensions, the distance to be measured shall be the shortest path the supply cord of an appliance connected to the receptacle would follow without piercing a floor, wall, ceiling, doorway with hinged or sliding door, window opening, or other effective permanent barrier »*680.34*«.

Caution

All electrical equipment, including power-supply cords, used with storable pools shall have GFCI or SPGFCI protection, as applicable. All receptacles rated 125 through 250 volts, 60 amperes or less and located within 20 ft (6.0 m) of the inside walls of a storable pool, storable spa, or storable hot tub shall have GFCI or SPGFCI protection. In determining these dimensions, the distance to be measured shall be the shortest path the supply cord of an appliance connected to the receptacle would follow without piercing a floor, wall, ceiling, doorway with hinged or sliding door, window opening, or other effective permanent barrier »*680.32*«.


Weatherproof In-Use Cover as Well as Listed and Identified as "Extra-Duty"
No Maximum Dimension
A
B
No Maximum Water Depth
C
No Bonding Required
GFCI-Protected Receptacle
D

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Spas and Hot Tubs

Receptacles providing spa or hot tub power shall not exceed 150 volts to ground and shall be GFCI protected »*680.43(A)(3)*«.

An indoor spa or hot tub shall comply with Article 680 provisions (Parts I and II) unless modified by 680.43 and shall be connected by a Chapter 3 approved wiring method. Listed spa and hot tub packaged units rated 20 amperes or less can be cord- and plug-connected to facilitate the removal or disconnection of the unit for maintenance and repair »*680.43* and *Exception No. 1*«.

The equipotential bonding requirements for perimeter surfaces in 680.26(B)(2) shall not apply to a listed self-contained spa or hot tub installed above a finished floor. For a dwelling unit(s) only, where a listed spa or hot tub is installed indoors, the wiring method requirements of 680.42(C) shall also apply »*680.43 Exceptions No. 2* and *No. 3*«.

All of the following shall be connected to the equipment grounding conductor: (1) electric equipment located within 5 ft (1.5 m) of the spa or hot tub's inside wall and (2) electric equipment associated with the spa or hot tub's circulating system »*680.43(F)*«.

A Luminaires, lighting outlets, and ceiling-suspended (paddle) fans located over the spa/hot tub less than 5 ft (1.5 m) from the spa or hot tub's inside walls shall be a minimum of 7 ft 6 in. (2.3 m) above the maximum water level and shall be GFCI protected unless the mounting height is at least 12 ft (3.7 m) »*680.43(B)(1)(a)* and *(b)*«.

B Luminaires meeting either (1) or (2) of the following requirements *and* protected by a GFCI can be installed less than 7 ft 6 in. (2.3 m) over a spa or hot tub:

1. Recessed luminaires having a glass or plastic lens and nonmetallic or electrically isolated metal trim, suitable for damp location use
2. Surface-mounted luminaires, with a glass or plastic globe, and a nonmetallic body or a metallic body isolated from contact, and suitable for use in damp locations »*680.43(B)(1)(c)*«.

C Luminaires, lighting outlets, and ceiling-suspended (paddle) fans located 12 ft (3.7 m) or more above the maximum water level do not require GFCI protection »*680.43(B)(1)(a)*«.

D Switches shall be located at least 5 ft (1.5 m) measured horizontally from the spa or hot tub's inside walls »*680.43(C)*«.

E A readily accessible, clearly labeled emergency shutoff or control switch for stopping the motor(s) that provide recirculating and jet system power shall be installed at least 5 ft (1.5 m) away, adjacent to, and within sight from the spa or hot tub. Note: This requirement does not apply to one-family dwellings »*680.41(A)*«.

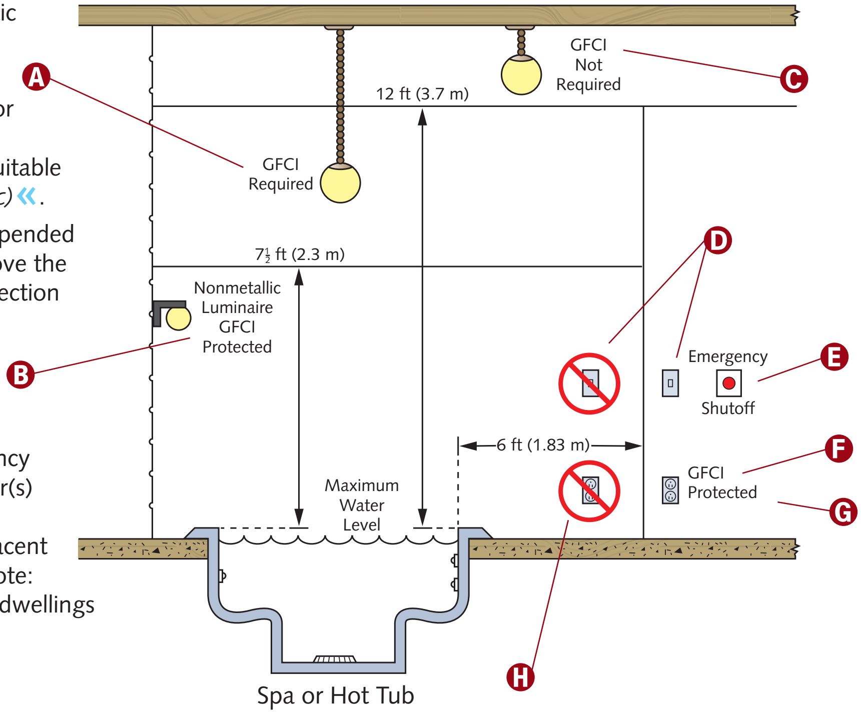
F All receptacles rated 125 volts through 250 volts, 60 amperes or less and within 10 ft (3.0 m) of the spa or hot tub's inside walls shall have GFCI or SPGFCI protection »*680.43(A)(2)*«. Determine this distance by measuring the shortest path the supply cord of an appliance connected to the receptacle would follow without piercing a building's floor, wall, ceiling, doorway with hinged or sliding door, window opening, or other effective permanent barrier »*680.43(A)(4)*«.

G At least one 125-volt, 15- or 20-ampere general-purpose branch-circuit receptacle shall be located a minimum of 6 ft (1.83 m), and no more than 10 ft (3.0 m), from the inside wall of an indoor spa or hot tub »*680.43(A)*«.

H Locate property receptacles at least 6 ft (1.83 m) measured horizontally from the spa or hot tub's inside walls »*680.43(A)(1)*«.

Note

A spa or hot tub installed outdoors shall comply with Article 680, Part I and II provisions except as permitted in 680.42(A) and (B). (A) Listed packages spa or hot tub equipment assemblies or self-contained spas or hot tubs utilizing a factory-installed or assembled control panel or panelboard shall be permitted to use flexible connections as covered in 680.42(A)(1) and (A)(2). (1) Liquidtight flexible metal conduit or liquidtight flexible nonmetallic conduit shall be permitted. (2) Cord and plug connections with a cord not longer than 15 ft (4.6 m) shall be permitted when GFCI protected ***»680.42«***.



Spa or Hot Tub
Installed Indoors

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Spas and Hot Tubs *(continued)*

Note

Bonding by metal-to-metal mounting on a common frame or base shall be permitted. The metal bands or hoops used to secure wooden staves shall not be required to be bonded as required in 680.26.

Equipotential bonding of perimeter surfaces in accordance with 680.26(B)(2) shall not be required to be provided for spas and hot tubs where all of the following conditions apply:

(1) The spa or hot tub shall be listed, labeled, and identified as a self-contained spa for aboveground use.
(2) The spa or hot tub shall not be identified as suitable only for indoor use.
(3) The installation shall be in accordance with the manufacturer's instructions and shall be located on or above grade.
(4) The top rim of the spa or hot tub shall be at least 28 in. (710 mm) above all perimeter surfaces that are within 30 in. (760 mm), measured horizontally from the spa or hot tub. The height of nonconductive external steps for entry to or exit from the self-contained spa shall not be used to reduce or increase this rim height measurement »*680.42(B)*«.

Pools and Tubs for Therapeutic Use

Except as otherwise provided in 680.62, the outlet(s) supplying the following shall be protected by a GFCI:
(1) self-contained therapeutic tub or hydrotherapeutic tank;
(2) packaged therapeutic tub or hydrotherapeutic tank; or
(3) field-assembled therapeutic tub or hydrotherapeutic tank »*680.62(A)*«.

If so marked, a listed, labeled, and identified self-contained unit or a listed, labeled, and identified packaged equipment assembly that includes integral ground-fault circuit-interrupter protection for all electrical parts within the unit or assembly (pumps, air blowers, heaters, lights, controls, sanitizer generators, wiring, and so forth) shall be permitted without additional GFCI protection »*680.62(A)(1)*«.

A therapeutic tub or hydrotherapeutic tank rated greater than 250 volts or rated 3-phase or with a heater load exceeding 50 amperes does not require supply protection by means of a GFCI »*680.62(A)(2)*«.

All receptacles within 6 ft (1.83 m) of a therapeutic tub shall have ground-fault protection »*680.62(E)*«.

A Article 680, Part I and Part VI provisions apply to therapeutically used pools and tubs in health care facilities, gymnasiums, athletic training rooms, and similar areas. Portable therapeutic appliances shall comply with Parts II and III of Article 422 »*680.60*«.

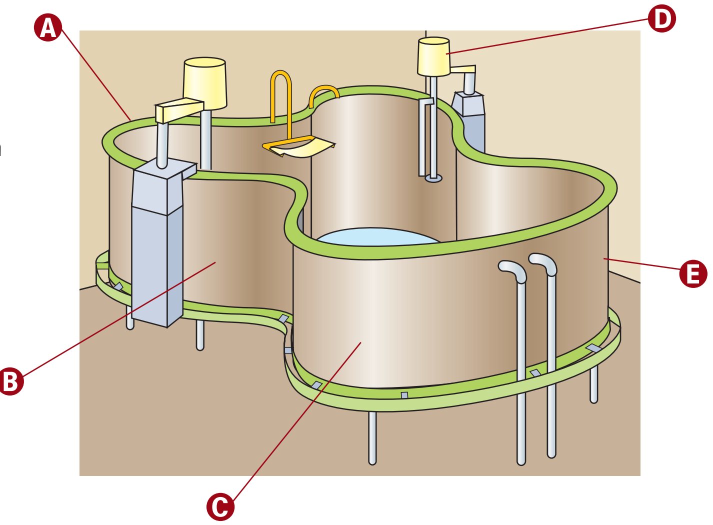
B All tub-associated metal parts shall be bonded by any of the following methods: (1) interconnection of threaded metal piping and fittings; (2) metal-to-metal mounting on a common frame or base; (3) suitable metal clamp connections; or (4) the provision of a solid copper bonding jumper (insulated, covered, or bare) no smaller than 8 AWG »*680.62(C)*«.

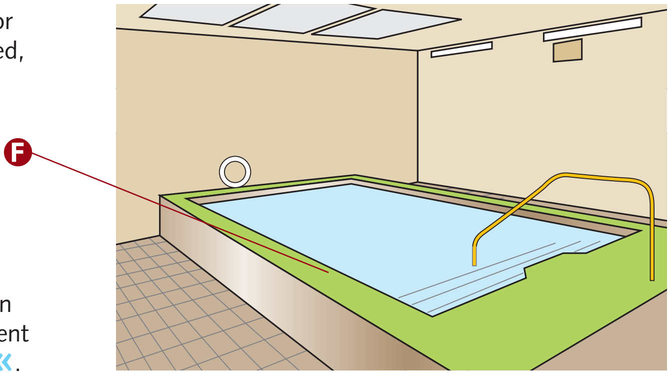
C Tubs used for the therapeutic submersion and treatment of patients, which during normal use are not easily moved from place to place, or which are fastened or secured at a given location (including associated piping systems), shall conform to Part VI of Article 680 »*680.62*«.

D All of the following shall be connected to an equipment grounding conductor: (1) electrical equipment located within 5 ft (1.5 m) of the tub's inside wall and (2) electrical equipment associated with the tub's circulating system »*680.62(D)(1)*«.

E The following parts shall be bonded together:

1. All metal fittings within, or attached to, the tub structure.
2. Metal parts of electrical equipment associated with the tub's water circulating system, including pump motors.
3. Metal-sheathed cables and raceways and metal piping within 5 ft (1.5 m) of the tub's inside walls and not separated from the tub by a permanent barrier.





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Pools and Tubs for Therapeutic Use *(continued)*

4. All metal surfaces within 5 ft (1.5 m) of the tub's inside walls not separated by a permanent barrier.
5. Electrical devices and controls unrelated to the therapeutic tubs shall either be located at least 5 ft (1.5 m) away from such units, or be bonded to the therapeutic tub system »*680.62(B)*«.

Ⓕ Therapeutic pools constructed in or on the ground or within a building in such a manner that the pool cannot be readily disassembled shall comply with Article 680, Parts I and II »*680.61*«. The limitations of 680.22(B)(1) through (B)(4) do not apply if all luminaires are of the totally enclosed type »*680.61 Exception*«.

Caution

All luminaires used in therapeutic tub areas shall be of the totally enclosed type »*680.62(F)*«.

Note

Small conductive surfaces not likely to become energized, such as air and water jets and drain fittings not connected to metallic piping, and towel bars, mirror frames, and similar nonelectrical equipment not connected to metal framing, shall not be required to be bonded ***»680.62(B) Exception«***.

Hydromassage Bathtubs

Hydromassage bathtubs as defined in Article 100 shall comply with Part VII of this article. They shall not be required to comply with other parts of this article »*680.70*«.

Ⓐ All bathroom receptacles shall have GFCI protection for personnel »*210.8(A)(1)* and *(B)(1)*«.

Ⓑ All 125-volt, single-phase receptacles not exceeding 30 amperes and located within 6 ft (1.83 m) measured horizontally of the inside walls of a hydromassage tub shall be protected by a ground-fault circuit interrupter »*680.71*«.

Ⓒ Hydromassage bathtubs and their associated electrical components shall be on an individual branch circuit(s) and protected by a readily accessible ground-fault circuit interrupter »*680.71*«.

Ⓓ All metal parts required to be bonded by 680.74 shall be bonded together using a solid copper bonding jumper, insulated, covered, or bare, not smaller than 8 AWG. The bonding jumper(s) shall be required for equipotential bonding in the area of the hydromassage bathtub and shall not be required to be extended or attached to any remote panelboard, service equipment, or any electrode. In all installations a bonding jumper long enough to terminate on a replacement non-double-insulated pump or blower motor shall be provided and shall be terminated to the equipment grounding conductor of the branch circuit of the motor when a double-insulated circulating pump or blower motor is used »*680.74(B)*«.

Ⓔ Hydromassage bathtub electrical equipment shall be accessible without damage to the building structure or finish. Where the hydromassage bathtub is cord- and plug-connected with the supply receptacle accessible only through a service access opening, the receptacle shall be installed so that its face is within direct view and not more than 1 ft (300 mm) of the opening »*680.73*«.

Note

Luminaires, switches, receptacles, and other electrical equipment located in the same room, and not directly associated with a hydromassage bathtub, shall be installed in accordance with the requirements of Chapters 1 through 4 in the *NEC* covering the installation of that equipment in bathrooms *»680.72«*.

Caution

A receptacle shall not be installed within a zone measured 3 ft (900 mm) horizontally and 8 ft (2.5 m) vertically from the outside edge of the bathtub or shower stall. The identified zone is all-encompassing and shall include the space directly over the tub or shower stall *»406.9(C)«*.

Warning

The GFCI protecting the hydromassage bathtub branch circuit shall be readily accessible »*680.71*«.

Note

The following parts shall be bonded together: (1) all metal fittings within or attached to the tub structure that are in contact with the circulating water; (2) metal parts of electrical equipment associated with the tub water circulating system, including pump and blower motors; (3) metal-sheathed cables, metal raceways, and metal piping that are within 5 ft (1.5 m) of the inside walls of the tub and not separated from the tub by a permanent barrier; (4) all exposed metal surfaces that are within 1.5 m (5 ft) of the inside walls of the tub and not separated from the tub area by a permanent barrier; and (5) non-current-carrying metal parts of electrical devices and controls that are not associated with the hydromassage tubs and that are located within 5 ft (1.5 m) from such units ***»680.74(A)«***.

Small conductive surfaces not likely to become energized, such as air and water jets, supply valve assemblies, and drain fittings not connected to metallic piping, and towel bars, mirror frames, and similar nonelectrical equipment not connected to metal framing shall not be required to be bonded ***»680.74(A) Exception No. 1«***.

Double-insulated motors and blowers shall not be bonded ***»680.74(A) Exception No. 2«***.

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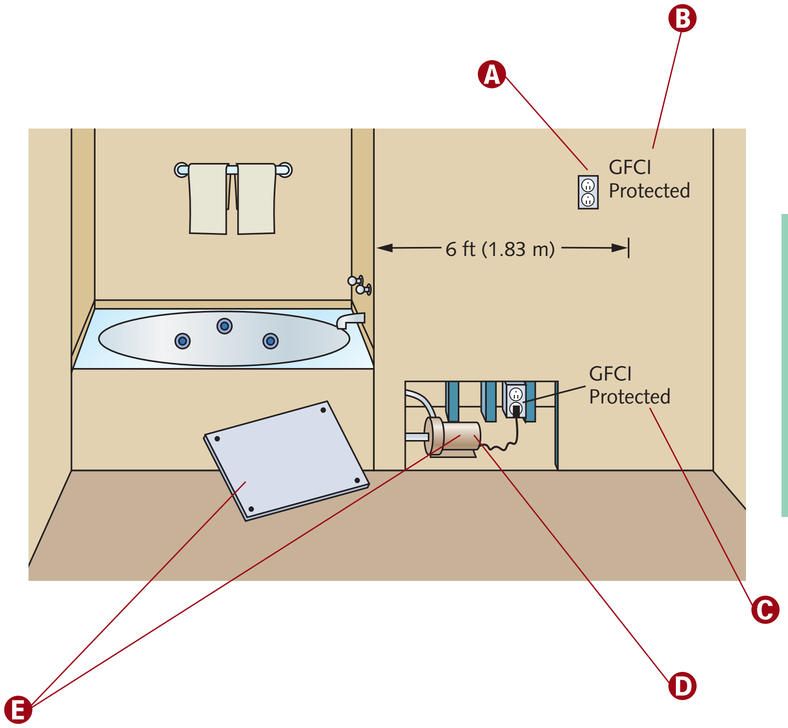
Hydromassage Bathtubs *(continued)*



Note

Small conductive surfaces of electrical equipment not likely to become energized, such as the mounting strap or yoke of a listed light switch or receptacle that is grounded, shall not be required to be bonded ***»680.74(A) Exception No. 3«***.

Summary

- Article 600 covers the conductor and equipment installation for electric signs and outline lighting (including neon and skeleton tubing).
- Manufactured wiring system provisions are located in Article 604.
- Article 605 ("Office Furnishings") covers electrical equipment, lighting accessories, and wiring systems used to connect, or contained within, or installed on office furnishings.
- Electric vehicle power transfer system provisions are located in Article 625.
- Audio signal processing, amplification, and reproduction equipment requirements can be found in Article 640.
- Article 645 covers information technology equipment.
- Electrically operated pipe organ circuits and components employed for sounding apparatus and keyboard control are located in Article 650.
- Article 695 ("Fire Pumps") covers the installation of electric power sources and interconnecting circuits as well as switching and control equipment dedicated to fire pump drivers.
- Elevator, dumbwaiter, escalator, moving walk, platform lift, and stairway chairlift provisions are contained in Article 620.
- Article 680 provisions apply to the construction and installation of electrical wiring and equipment in or near all swimming, wading, therapeutic, and decorative pools, fountains, hot tubs, spas, and hydromassage bathtubs, whether permanently installed or storable, as well as to metallic auxiliary equipment (such as pumps, filters, etc.).
- The parts specified in 680.26(B)(1) through (B)(7) shall be bonded together using solid copper conductors, insulated, covered, or bare, not smaller than 8 AWG or with rigid metal conduit of brass or other identified corrosion-resistant metal.
- Very specific and detailed receptacle and lighting (including underwater) requirements are stipulated in Article 680.
- While Article 680, Part II covers permanently installed pools, requirements for storable pools, storable spas, and storable hot tubs are found in Part III.
- Indoor spa and hot tub installations are covered in 680.43(A) through (G).
- Article 680, Part VI provisions apply to pools and tubs for therapeutic use in health care facilities, gymnasiums, athletic training rooms, and similar areas.
- Hydromassage bathtubs (and associated electrical components) are covered in Article 680, Part VII.

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Unit 19 Competency Test

***NEC*® Reference** **Answer**

____________ ____________ 1. Storable swimming pools are pools installed ____________ that are intended to be stored when not in use.

____________ ____________ 2. Overcurrent protection for feeders and branch circuits supplying electric vehicle supply equipment (EVSE) and wireless power transfer equipment (WPTE), including bidirectional EVSE, and WPTE shall be sized for ____________ duty and shall have a rating of not less than ____________ % of the maximum load of the equipment.

____________ ____________ 3. A clearly labeled emergency shutoff or control switch for the purpose of stopping the motor(s) that provide power to the recirculation system and jet system shall be installed at a point readily accessible to the users and at least ____________ ft away, adjacent to, and within sight from every spa or hot tub installed in other than single family dwelling units.

____________ ____________ 4. Transformers and power supplies used for the supply of underwater luminaires in swimming pools shall incorporate either a transformer of the isolated winding type with an ungrounded secondary that has a ____________ between the primary and secondary windings or one that incorporates an approved system of double insulation between the primary and secondary windings.

____________ ____________ 5. Duty on elevator driving machine motors shall be rated as ____________.

____________ ____________ 6. Not more than ____________ ft of high-voltage cable shall be permitted in nonmetallic conduit from a high-voltage terminal of a neon transformer (over 1000 volts, nominal) supply to the first neon tube.

____________ ____________ 7. All fixed metal parts that are within ____________ ft horizontally of the inside walls of a permanently installed swimming pool and within ____________ ft above the pool's maximum water level shall be bonded.

____________ ____________ 8. All receptacles within ____________ ft of a therapeutic tub shall be protected by a ground-fault circuit interrupter.

____________ ____________ 9. All live parts of electrical apparatus in elevator hoistways, at the landings, in or on the cars of elevators and dumbwaiters, in the wellways or the landings of escalators or moving walkways, or in the runways and machinery spaces of platform lifts and stairway chairlifts shall be ____________.

____________ ____________ 10. Unless specifically listed and marked for the location, the coupling means of the electric vehicle supply equipment (EVSE) shall be stored or located at a height of not less than ____________ in. above the floor level for indoor locations and ____________ in. above the grade level for outdoor locations.

____________ ____________ 11. A(n) ____________ is a structure designed to support a wet-niche luminaire assembly and intended for mounting in a pool or fountain structure.

____________ ____________ 12. Switches, flashers, and similar devices controlling transformers and electronic power supplies for electric signs shall be rated for controlling inductive loads or have a current rating not less than ____________ of the current rating of the transformer or the electric power supply.

a) 80% b) 100% c) 125% d) 200%

____________ ____________ 13. Audio system equipment supplied by branch-circuit power shall not be placed horizontally within ____________ ft of the inside wall of a pool, spa, hot tub, or fountain, nor within ____________ ft of the prevailing or tidal high water mark.

____________ ____________ 14. Where a permanently installed pool is installed, at least one 125-volt, 15- or 20-ampere receptacle on a general-purpose branch circuit shall be located a minimum of __________ ft from and not more than __________ ft from the inside wall of the pool.

____________ ____________ 15. The voltage at a fire pump controller's line terminals shall not drop more than __________ below normal (controller-rated voltage) under motor starting conditions unless special conditions are met.

***NEC*® Reference** **Answer**

____________ ____________ 16. Luminaires located over a spa or within 5 ft (1.5 m) from the inside walls of the spa shall be permitted to be not less than ____________ ft above the maximum water level where protected by a GFCI.

____________ ____________ 17. Traveling cables that are suitably supported and protected from physical damage shall be permitted to be run without the use of a raceway from inside the hoistway, to elevator controller enclosures and to elevator car and machine room, control room, machinery space, and control space connections that are located outside the hoistway for a distance not exceeding ____________ ft in length as measured from the first point of support on the elevator car or hoistway wall, or counterweight where applicable, provided the conductors are grouped together and taped or corded, or in the original sheath.

____________ ____________ 18. Information technology equipment shall be permitted to be connected to a branch circuit by a power-supply cord; the power-supply cord shall not exceed ____________ ft.

____________ ____________ 19. Hydromassage bathtub electrical equipment shall be ____________ without damaging the building structure or building finish.

____________ ____________ 20. All receptacles rated 125 volts through 250 volts, 60 amperes or less, located within ____________ ft of the inside wall of a pool shall have GFCI or SPGFCI protection.

____________ ____________ 21. Manufactured wiring systems cable shall be listed Type AC cable or listed Type MC cable containing nominal 600-volt, ____________ AWG insulated copper or copper-clad aluminum conductors.

____________ ____________ 22. Luminaires mounted in permanently installed swimming pool walls shall be installed with the top of the luminaire lens at least ____________ in. below the normal water level of the pool, unless the luminaire is listed and identified for use at lesser depths.

____________ ____________ 23. Sign or outline lighting system equipment shall be at least ____________ ft above areas accessible to vehicles unless protected from physical damage.

____________ ____________ 24. Existing luminaires and lighting outlets located less than ____________ ft measured horizontally from the inside walls of a pool shall be at least ____________ ft above the surface of the maximum water level, shall be rigidly attached to the existing structure, and shall be protected by a ground-fault circuit interrupter.

____________ ____________ 25. A fixed or stationary electric sign installed within a fountain shall be at least ____________ ft inside the fountain measured from the outside edges of the fountain.

____________ ____________ 26. The conductors to an elevator hoistway door interlock from the hoistway riser shall be flame retardant and suitable for a temperature of not less than ____________.

____________ ____________ 27. In new outdoor pool areas, ceiling-suspended (paddle) fans shall not be installed above the pool or over the area extending ____________ ft horizontally from the inside walls of the pool unless the fan is installed at least ____________ ft above the maximum water level.

____________ ____________ 28. The branch-circuit conductors supplying one or more units of information technology equipment shall have an ampacity not less than ____________ of the total connected load.

____________ ____________ 29. A junction box connected to a conduit that extends directly to a forming shell of a no-niche luminaire in a permanently installed swimming pool shall be provided with a number of grounding terminals that shall be ____________.

____________ ____________ 30. A(n) ____________ is a device external to the electric vehicle that transfers power via the contactless coupling as part of a wireless power transfer system.

____________ ____________ 31. Branch circuits that supply neon tubing installations shall not be rated in excess of ____________.

____________ ____________ 32. The termination of the 8 AWG bonding jumper in a permanently installed swimming pool forming shell shall be covered with or encapsulated in a(n) ____________ to protect the connection from the possible deteriorating effect of pool water.

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NEC® Reference	Answer	
___________	___________	33. Conductors supplying a fire pump motor(s), pressure maintenance pumps, and associated fire pump accessory equipment shall have a rating not less than ___________ of the sum of the fire pump motor(s) and pressure maintenance motor(s) full-load current(s), and ___________ of the associated fire pump accessory equipment full-load current(s).
___________	___________	34. Switching devices shall be located at least ___________ ft horizontally from the inside walls of a pool unless separated from the pool by a solid fence, wall, or other permanent barrier that provides at least a ___________ ft reach distance.
___________	___________	35. Article ___________ covers electrical equipment, lighting accessories, and wiring systems used to connect, contained within, or installed on office furnishings.
___________	___________	36. A junction box connected to a conduit that extends directly to a forming shell for an underwater luminaire in a permanently installed swimming pool shall be located not less than ___________ in., measured from the inside of the bottom of the box, above the ground level, or pool deck, or not less than ___________ in. above the maximum pool water level, whichever provides the greater elevation if operating above the low-voltage contact limit.
___________	___________	37. Vertical runs of wireways, used in elevator installations, shall be securely supported at intervals not exceeding ___________ ft and shall have not more than one joint between supports.
___________	___________	38. Where receptacles are used as a means of connecting sensitive electronic equipment, a 125-volt, single-phase, 15- or 20-ampere-rated receptacle having one of its current-carrying poles connected to a grounded circuit conductor shall be located within ___________ ft of all permanently installed 15- or 20-ampere-rated 60/120-volt technical power-system receptacles.

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